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National Water Quality Inventory

1998 Report To Congress

Ground Water and Drinking Water Chapters

COVER PHOTOGRAPH: In 1946 the Department of Interior and the United Mine Workers agreed to a joint survey of medical, health and housing conditions in coal communities to be conducted by Navy personnel. Under the direction of Rear Admiral Joel T. Boone, survey teams went into mining areas to collect data and photographs on the conditions of these regions, later compiled into a published report titled A Medical Survey of the Bituminous-Coal Industry, 1947. The bulk of the photographs were taken by Russell W. Lee, a professional photographer hired by the Department of Interior for this project. These photographs cover a complete range of activities in mining communities including drawing water from a well as reproduced for the cover of this report.

Photograph No. NWDNS-245-MS-1279L (Photographer, Russell W. Lee); "Drawing water from well at farm house where annual reunion of England family was held. Hensley Hollow, McDowell County, West Virginia," August 11, 1946; Still Picture Branch; Record Group 245; National Archives at College Park, College Park, MD.

Preface

This bulletin contains the ground water chapters and drinking water sections from the *National Water Quality Inventory, 1998 Report to Congress* (305(b) report). As the primary vehicle for informing Congress and the public about general water quality conditions in the United States, the 305(b) report summarizes information related to the quality of our nation's water resources as reported by states, territories, and American Indian tribes in their water quality assessment reports. Under Section 305(b), the Clean Water Act requires that the states and other participating jurisdictions submit water quality assessment reports every 2 years and that the U.S. Environmental Protection Agency (EPA) summarize the state reports and provide the information to Congress biennially. Most of the survey information in the 1998 national report is based on water quality information collected and evaluated by the states, territories, and tribes during 1996 and 1997.

Information contained in this bulletin describes the quality of our nation's ground water resources and the assessments conducted to determine the quality of water used for drinking water. This is the first time that the information on drinking water assessments is included in this bulletin. Using information from the 1998 Section 305(b) reports, the first two sections characterize our nation's ground water quality, identify widespread ground water quality problems of national significance, and describe various programs implemented to restore and protect our ground water resources. The third section on drinking water assessments contains information on state use of assessment criteria, percentages of waters assessed, and sources of impairment submitted by the states.

An important trend observed in 1998 was the use of monitoring results to streamline and focus state ground water monitoring programs. Many states have established state-wide monitoring programs and implemented improvements to support sound decision making. The monitoring of selected aquifers to establish baseline parameters also has taken hold in many states. Several states are beginning to improve communication and data sharing among state agencies and are also showing progress in the use of modern system technologies in evaluating the results of state monitoring. Furthermore, more states are reporting on the assessments for drinking water use and increasing the numbers of waterbodies assessed. Included in the state reports is information on the classification of waterbodies, contaminant sources, and the level of assessments. Continuation of these trends will surely improve the quality of data and provide more representative and consistent data throughout the state programs.

The Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA) play a complementary role in the protection of ground water and the assessment of waters designated for drinking water use. The SDWA calls for states to determine the susceptibility of source waters to contamination, while the CWA calls for them to assess the ability of the waters to support drinking water use. Ensuring consistently safe drinking water requires the cooperation of federal, state, tribal, and municipal governments to protect source water from pollution. The states are central in creating and focusing prevention programs and helping water systems improve their operations to avoid contamination problems. This integration of protection and assessment programs promotes the opportunities to better protect public health and the environment.

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Acknowledgments

The 1998 State Water Quality Assessments submitted to the U.S. Environmental Protection Agency (EPA) by states, territories, and American Indian tribes contained a wealth of information on water quality and monitoring. This bulletin is based primarily on that information, but other information from other federal agencies and offices outside the Office of Ground Water and Drinking Water (OGWDW) was used to make the report more comprehensive. The EPA wishes to thank all the EPA personnel who contributed to this report, but special thanks are due to the authors of the state ground water assessments for their time and effort spent in preparing these reports and in reviewing the drafts of this national assessment. Additional thanks are extended to the water quality assessment coordinators from the EPA regional offices that work with the states, tribes, and other jurisdictions.

The OGWDW project manager and chief editor of this document was A. Roger Anzzolin of the Information Management Branch, Implementation and Assistance Division (IAD), Office of Ground Water and Drinking Water. Key contributions also were made by the following IAD individuals: Steve Ainsworth, Rob Allison, Janet Auerbach, Thomas Belk, Jori Copeland, Robyn Delehanty, Debra Gutenson, Betsy Henry, Lisa Kahn, James Hamilton, Harriet Hubbard, Bruce Kobelski, Kevin McCormack, and Roy Simon. Ken Lovelace of the Office of Solid Waste and Emergency Response; Mark Barolo of the Office of Underground Storage Tanks; Susan Holdsworth of the Office of Wetlands, Oceans, and Watersheds; Chuck Evans, Arty Williams, and Estella Waldman of the Office of Pesticide Programs; and Jill Nogi of U.S. EPA Region 10 also made key contributions to the protection chapter.

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John H. McShane, Yellowstone National Park

Ground Water Quality

Ground water is a vital national resource that is used for myriad purposes. It is used for

- Public and domestic water supply systems

- Irrigation and livestock watering

- Industrial, commercial, mining, and thermoelectric power production purposes.

In many parts of the nation, ground water serves as the only reliable source of drinking and irrigation water. Unfortunately, this vital resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the country.

This 1998 report represents the second 305(b) cycle of data collection based on ground water guidelines introduced to states as part of the 1996 305(b) reporting cycle.

This chapter presents the results of data submitted by 37 states, 3 territories, 4 tribes, and the District of Columbia in their 1998 305(b) water quality reports. States (a term used to include territories, tribes, and the District of Columbia) reported ground water monitoring data for a total of 146 aquifers or hydrogeologic settings. Based on these results, ground water quality in the nation is good and can support the many different uses of this resource. Despite these very positive results, aquifers across the nation are showing measurable impacts stemming from human activities. Through monitoring, elevated levels of petroleum hydrocarbon compounds, volatile organic compounds, nitrate, pesticides, and metals have been detected in ground water across the nation. The detection of some contaminants in ground water (e.g., metals and MTBE) is relatively new and is increasing. With each successive 305(b) report, emerging trends in ground water contaminants will become evident.

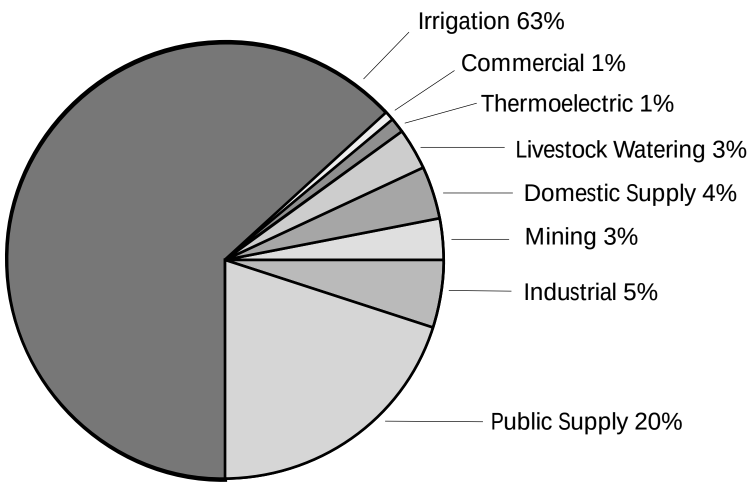
Ground Water Use in the United States

Ground water is an important component of our nation's fresh water resources. The use of ground water is of fundamental importance to human life and is also significant to economic vitality. Inventories of ground water and surface water use patterns in the United States emphasize the importance of ground water. The United States Geological Survey (USGS) compiles national water use information every 5 years and publishes a report that summarizes this information. The latest USGS report was issued in October 1998 for the 1995 water year.

The USGS report shows that ground water provides water for drinking and bathing, irrigation of crop lands, livestock watering, mining, industrial and commercial uses, and thermoelectric cooling

Figure 1

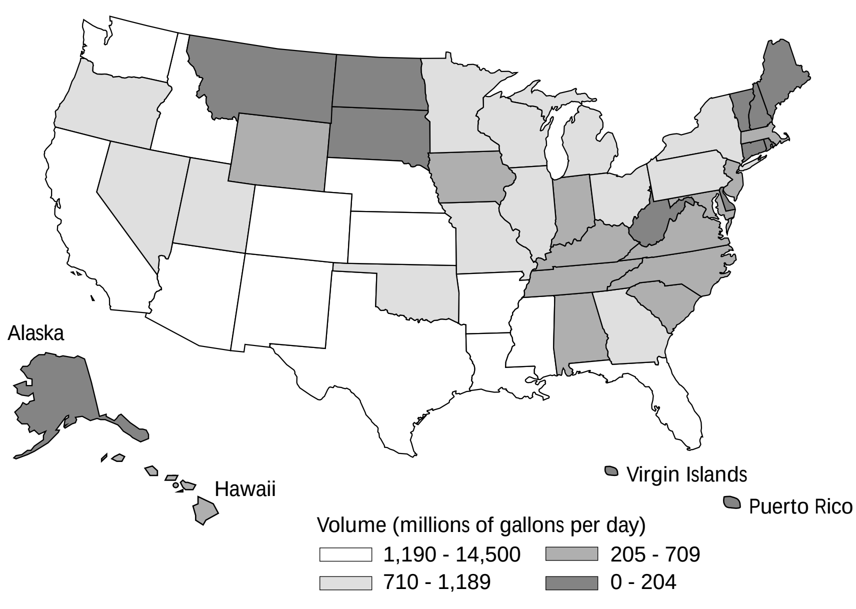
National Ground Water Use



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

Figure 2

Ground Water Withdrawals by State in 1995



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

applications. Figure 1 illustrates how ground water use is proportioned among these categories. As shown, irrigation (63%) and public water supply (20%) are the largest uses of ground water.

About 77,500 million gallons of ground water are withdrawn daily. In 1995, the USGS reported that ground water supplied 46% of the nation's overall population and 99% of the population in rural areas with drinking water. Our nation's dependence on this valuable resource is clear.

Every state uses some amount of ground water. Nineteen states obtain more than 25% of their overall water supply from ground water. Ten states obtain more than 50% of their total water supply from ground water.

Each state uses its ground water differently. Ground water use in individual states is a result of numerous interrelated factors generally associated with geography and climate, the principal types of business activities occurring in the state, and population distribution. Fresh ground water withdrawals during 1995 were highest generally in the western states, primarily to supply an increasing population and to sustain important agricultural activities. Figure 2 shows the volume of ground water withdrawn by states. The 13 states that have the greatest withdrawals account for 69% of all ground water that is withdrawn nationally.

Overall, agricultural activities account for the majority of ground water used in the nation. Figure 3 shows the volume of ground water used for irrigation. Irrigation is important for maintaining yields from crop land in the western and southeastern states. Generally, 75% or more of harvested crop land in many of the western states is irrigated, which represents an important ground water use. Watering of livestock also accounts for significant withdrawals of fresh ground water. Of all the states, California uses the greatest volume of ground water supplies to support agriculture.

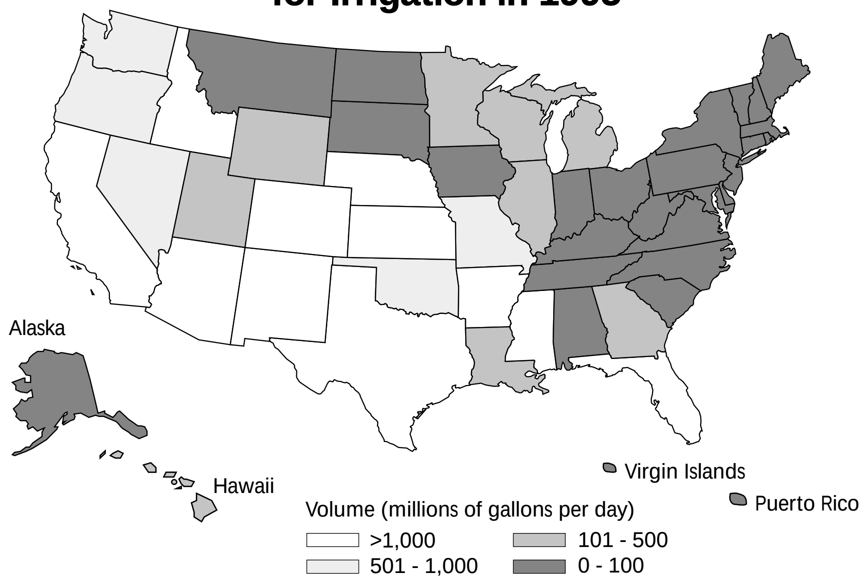
Ground water use trends between 1950 and 1995 generally reflected the observed trends for total water use for the nation (Figure 4). From 1950 through 1980, there was a steady increase in fresh ground water withdrawals, which coincided with the steady increase in our nation's total water use. Use of fresh water generally declined after 1980 through 1995, and fresh ground water withdrawals declined in 1995 to nearly 10% less than estimated in 1980. This decline occurred as the nation's population increased 16% over this 15-year period.

The current decline in water use, including ground water use, is attributed primarily to growing recognition in recent years that water is not an unlimited resource. Conservation programs championed by state and local communities lowered public supply per capita use over the same 15-year period.

Two factors are contributing to a lessening demand for water. First, an increase in dry farming practices has decreased the acres of irrigated lands in the west and, thus, has decreased the demand for fresh ground water in this region. Second, improved and more efficient irrigation systems and techniques have contributed to water conservation.

Figure 3

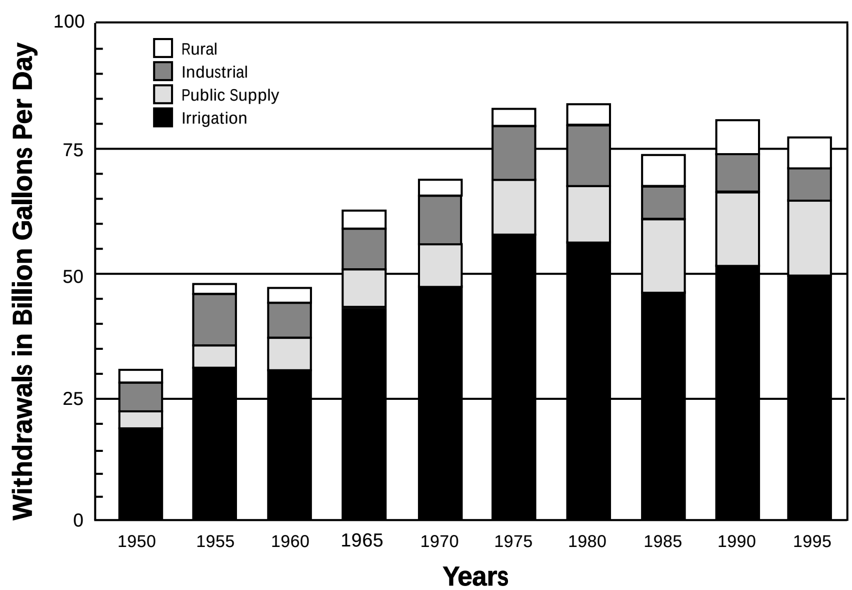
Volume of Ground Water Used for Irrigation in 1995



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

Figure 4

Ground Water Withdrawals in the United States, 1950-1995



Source: http://wwwga.usgs.gov/edu/earthgwusetrend.html

Industry has also improved the efficiency of its manufacturing operations by focusing on water conservation. For example, water recycling practices by industries, adopted to reduce discharges as well as operating costs, have been one important development in the conservation of water in industry.

Ground water continues to be an important component of our nation's water supply. The demand for ground water to meet the nation's needs must be coupled with supply-management practices to conserve this valued resource.

Ground Water Quality

The evaluation of our nation's ground water quality is complex. In evaluating ground water quality under Section 305(b) of the Clean Water Act, our goal is to determine if the resource meets the requirements for its many different uses. Ground water quality can be adversely affected or degraded as a result of human activities that introduce contaminants into the environment. It can also be affected by natural processes that result in elevated concentrations of certain constituents in the ground water. For example, elevated metal concentrations can result when metals are leached into the ground water from minerals present in the earth. High levels of arsenic and uranium are frequently found in ground water in some western states.

Not too long ago, it was thought that soil provided a protective "filter" or "barrier" that immobilized the downward migration of contaminants released on the land surface. Soil was supposed to prevent ground water resources from being contaminated. The detection of pesticides and other contaminants in ground water demonstrated that these resources were indeed vulnerable to contamination. The potential for a contaminant to affect ground water quality is dependent upon its ability to migrate through the overlying soils to the underlying ground water resource.

Ground water contamination can occur as relatively well-defined, localized plumes emanating from specific sources such as leaking underground storage tanks, spills, landfills, waste lagoons, and/or industrial facilities (Figure 5). Contamination can also occur as a general deterioration of ground water quality over a wide area due to diffuse nonpoint sources such as agricultural fertilizer and pesticide applications. Ground water quality degradation from diffuse nonpoint sources affects large areas, making it difficult to specify the exact source of the contamination.

Ground water contamination is most common in highly developed areas, agricultural areas, and industrial complexes. Frequently, ground water contamination is discovered long after it has occurred. One reason for this is the slow movement of ground water through aquifers, sometimes as little as fractions of a foot per day. This often results in a delay in the detection of ground water contamination. In some cases, contaminants introduced into the subsurface decades ago are only now being discovered. This also means that the environmental management practices of today will have effects on ground water quality well into the future.

Sources of Ground Water Contamination

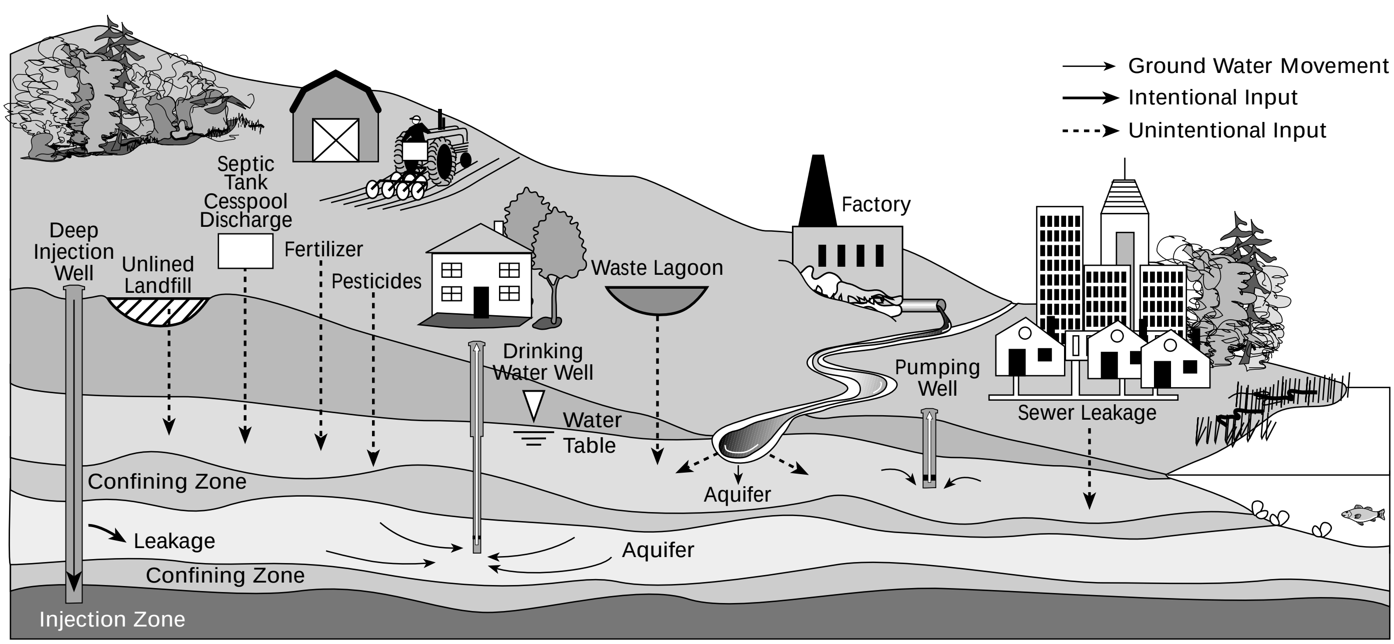
Ground water quality may be adversely impacted by a variety of potential contaminant sources. It can be difficult to identify which sources have the greatest impact on ground water quality because each source varies in the amount of ground water it contaminates. In addition, each source impacts water quality differently.

An EPA/state workgroup developed a list of potential contaminant sources and requested each state to indicate the 10 top sources that potentially threaten their ground water resources. States added sources as was necessary based on state-specific concerns. When selecting sources, states considered numerous factors, including

- The number of each type of contaminant source in the state
- The location relative to ground water sources used for drinking water purposes
- The size of the population at risk from contaminated drinking water
- The risk posed to human health and/or the environment from releases
- Hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers)
- The findings of the state's ground water assessments and/or related studies.

Figure 5

Sources of Ground Water Contamination



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Ground Water and Surface Water – A Single Resource

Traditionally, surface water and ground water have been treated as separate entities in the management of water resources. More recently, however, it has become apparent that all waterbody interaction is interrelated. Water in lakes, wetlands, and streams recharges ground water reservoirs, and ground water discharges back into lakes, wetlands, and streams, providing baseflow maintenance. A recent report by the USGS, *Ground Water and Surface Water – A Single Resource*, summarizes these interactions (USGS Circular 1139, 1998).

Ground water contributes to most streams, thereby maintaining streamflow during periods of low flow or drought. The ground water component of streamflow is variable across the country. In one USGS study, 24 regions were delineated on the basis of physiography and climate. Ground water and surface water interactions (i.e., ground water contribution to streamflow) were considered to be similar in each of these regions. Fifty-four streams, with at least two streams in each region, were selected to study ground water and surface water interactions. Daily stream flow values for the 30-year period, 1961 to 1990, were used for the analysis of each stream. The analysis indicated that an average of 52% of all the streamflow in the nation was contributed by ground water. Ground water contributions ranged from 14% to 90%. The ground water contribution to streamflow for selected streams is compared in the figure.

Development of surface water resources can affect ground water resources and vice versa. Large withdrawals of ground water can reduce the amount of ground water inflow to surface water and significantly reduce the supplies of surface water available to downstream users. Increased demands on our water resources prior to the 1980 water year (USGS Circular 1200, 1998) caused many surface water supplies to be depleted, particularly in some western states. The use of large volumes or amounts of ground water for irrigation was often identified as the cause of drying river beds and wetlands. Today, conservation and changes in agricultural practices are restoring flow to these rivers and also to ecologically important wetlands areas.

The water quality of each of these resources can also be affected by their interactions. Water quality can be adversely affected when

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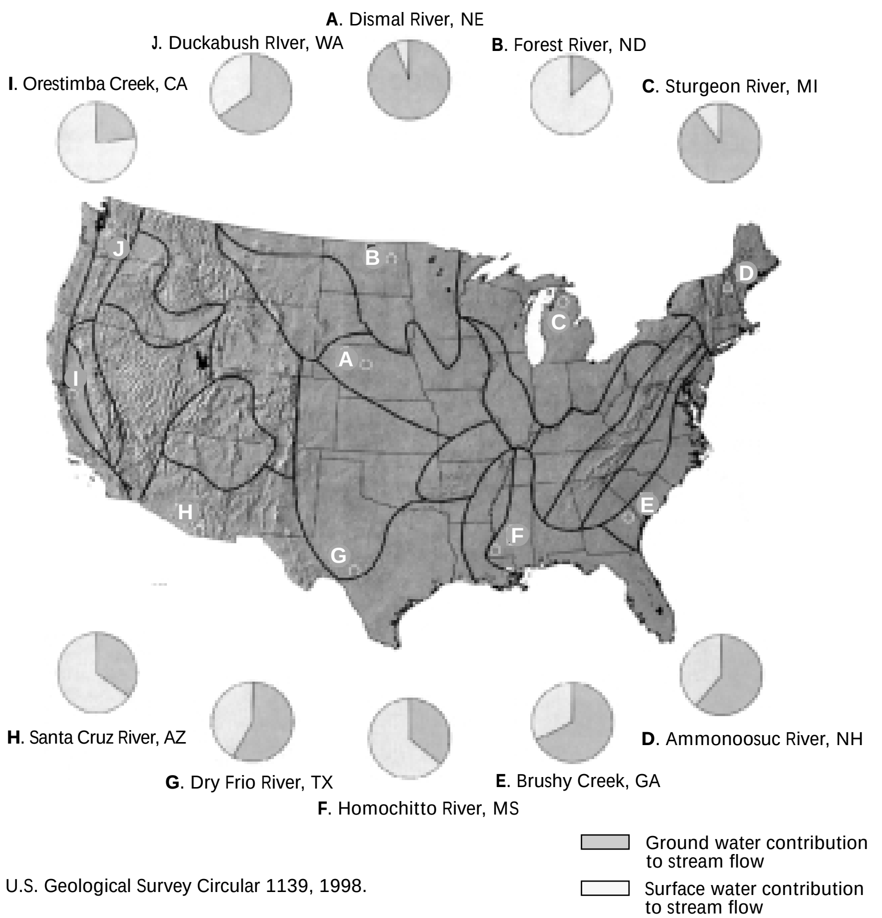
nutrients and contaminants are transported between ground water and surface water. For example, contaminants in streams can affect ground water quality during periods of recharge and flooding. Polluted ground water can affect surface waterbodies when contaminated ground water discharges into a river or stream. Because contamination is not restricted to either waterbody, both ground water and surface water must be considered in water quality assessments.

Coordination between surface water and ground water programs will be essential to adequately evaluate the quality and quantity of our nation's drinking water. Ground water and surface water interactions have a major role in affecting chemical and biological processes in lakes, wetlands, and streams, which in turn affect water quality throughout the system. An understanding of these interactions is critical in our water protection and conservation efforts. It is evident that protection of ground water, as much as protection of surface water, is of major importance for sustaining uses such as drinking water supply, fish and wildlife habitats, swimming, boating, and fishing.



U.S. Geological Survey Circular 1139, 1998.

This map compares ground water contribution to streamflow for selected streams.

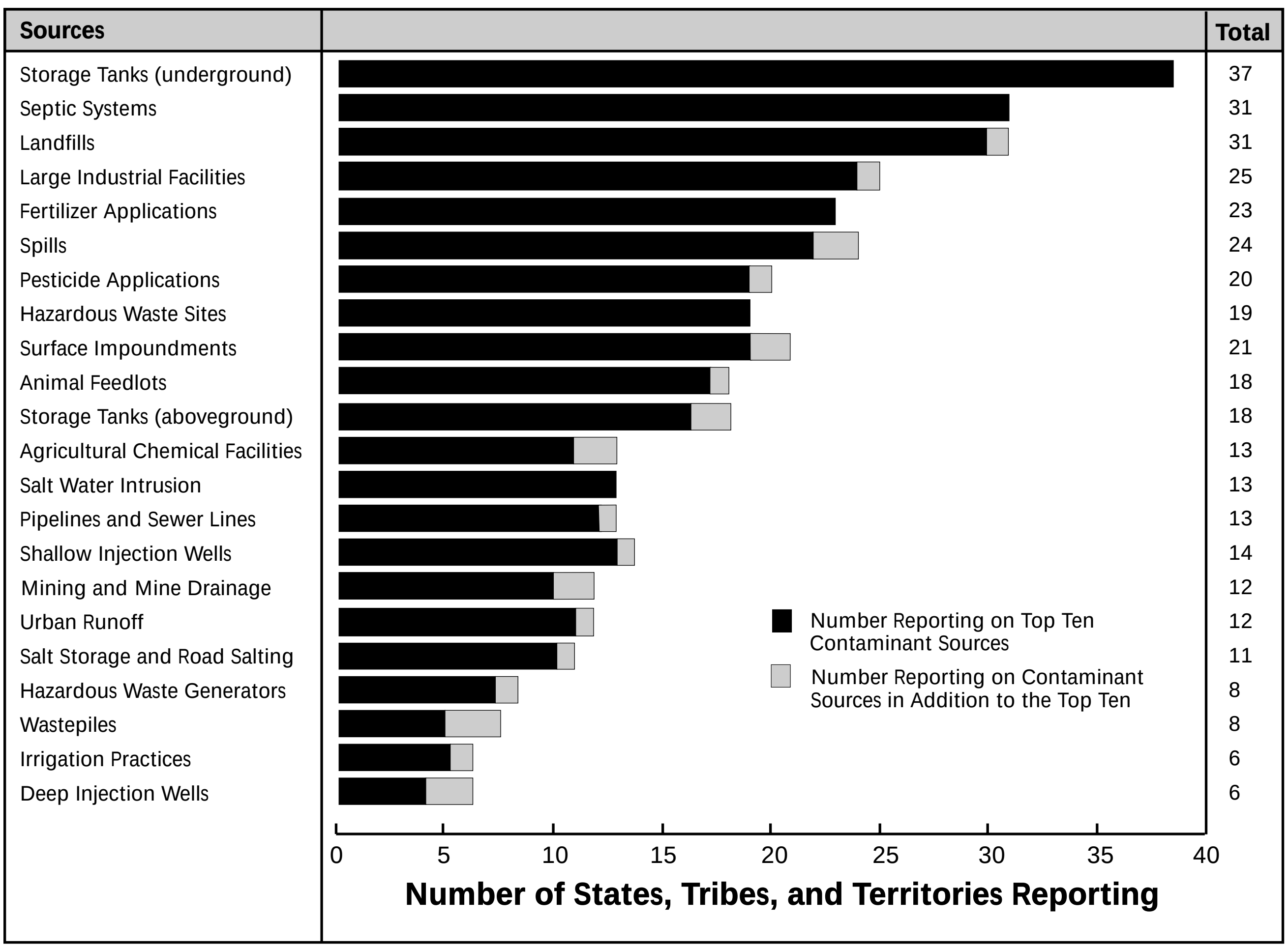
For each of the 10 top sources, states identified the specific contaminants that may impact ground water quality. Figure 6 illustrates the sources most frequently cited by states as a potential threat to ground water quality. Leaking underground storage tanks (LUSTs) are the greatest potential source of ground water contamination. Septic systems, landfills, industrial facilities, and fertilizer applications are the next most frequently cited sources of concern. These findings are consistent with state reports during previous 305(b) cycles.

If similar sources are combined, four broad categories emerge as the most important potential sources of ground water contamination:

- Fuel storage practices
- Waste disposal practices
- Agricultural practices
- Industrial practices.

Figure 6

Major Sources of Ground Water Contamination



Fuel Storage Practices

Fuel storage practices include the storage of petroleum products in underground and aboveground storage tanks. Although tanks exist in all populated areas, they are generally most concentrated in the more heavily developed urban and suburban areas of a state.

Storage tanks are primarily used to hold petroleum products such as gasoline, diesel fuel, and fuel oil. Leakages can be a significant source of ground water contamination (Figure 7). The primary causes of tank leakages are faulty installation or corrosion of tanks and pipelines.

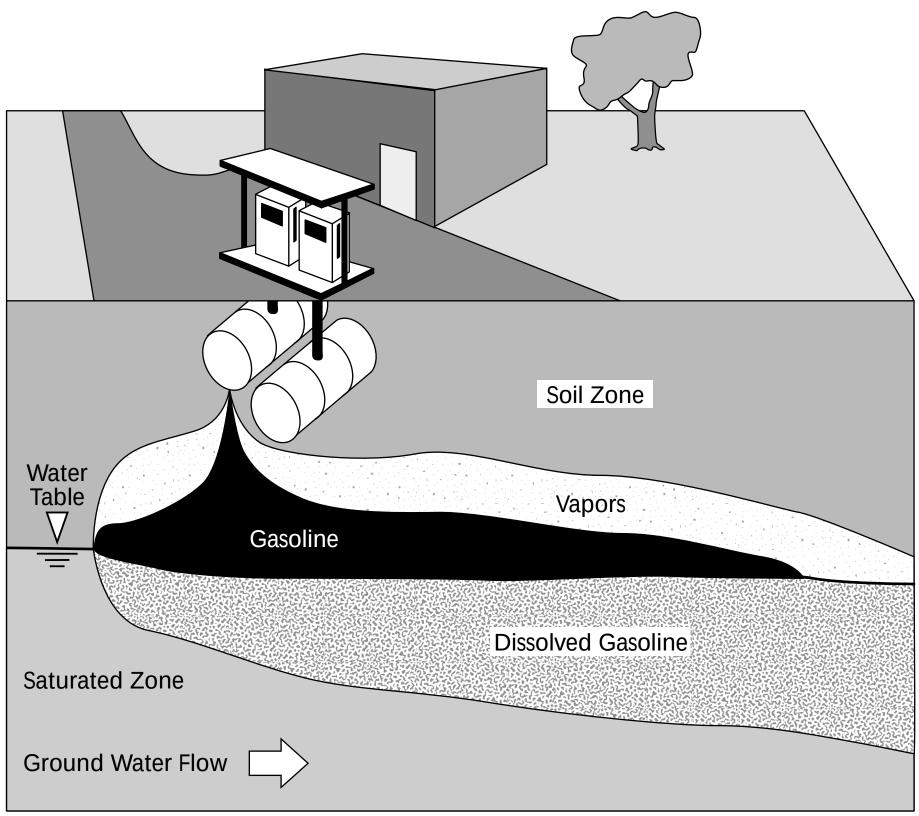
Petroleum products are actually complex mixtures of hundreds of different compounds. Over 200 gasoline compounds can be separated in the mixture. Compounds characterized by a higher water solubility are frequently detected in ground water resources. Four compounds, in particular, are associated with petroleum contamination: benzene, toluene, ethylbenzene, and xylenes. Petroleum-related chemicals threaten the use of ground water for human consumption because some (e.g., benzene) are known to cause cancer even at very low concentrations.

Compounds are added to some fuel products to improve performance. For example, methyl tert-butyl ether (MTBE) is added to boost octane and reduce carbon monoxide and ozone levels. Unfortunately, this compound is highly water soluble and incidents of MTBE contamination in ground water are widely reported across the nation. States report that MTBE is frequently being added to the list of compounds monitored at petroleum release sites. Thus, a new threat to ground water quality has been identified just in the past 5 years.

States report that the organic chemicals associated with petroleum products are common ground water contaminants. Petroleum-related chemicals adversely affect ground water quality in aquifers across the nation. The most significant impacts occur in the uppermost aquifer, which is frequently shallow and often used for domestic purposes.

Figure 7

Ground Water Contamination as a Result of Leaking Underground Storage Tanks



Efforts to Fight Air Pollution Create a Water Quality Concern

What began as an effort to fight air pollution became a water quality concern that necessitated dozens of costly studies and created a public health risk. Although methyl tert-butyl ether (MTBE) helps lower tailpipe emissions, it also contaminates ground water supplies. MTBE is more soluble in water and less likely to be degraded than other common petroleum constituents. It is also tentatively classified as a possible human carcinogen by EPA. In studies conducted by the USGS, MTBE was the second most commonly detected volatile organic compound (VOC) in water collected from urban wells and the seventh most commonly detected VOC in urban stormwater. Although frequently detected, only 3% of the urban wells sampled were characterized by concentrations of MTBE that exceeded EPA's draft drinking water health advisory level of 20 micrograms/liter. All of the concentrations measured in urban stormwater were less than the health advisory level.

Waste Disposal Practices

Waste disposal practices include

- Septic systems
- Landfills
- Surface impoundments
- Deep and shallow injection wells
- Wastepiles
- Waste tailings
- Land application
- Unpermitted disposal.

Any practice that involves the handling and disposal of waste has the potential to impact the environment if protective measures are not taken. Contaminants most likely to impact ground water include metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), nitrates, radionuclides, and pathogens. States report that current laws and regulations go a long way toward preventing releases and that many instances of present-day ground water contamination are the result of historic practices.

Improperly constructed and poorly maintained septic systems are believed to cause substantial and widespread nutrient and microbial contamination to ground water. In Montana, approximately 126,000 individual onsite septic systems are used by 252,000 people, and ground water monitoring has shown elevated nitrate levels near areas of concentrated septic systems. Widespread nitrate contamination by individual septic systems and municipal sewage lagoons is a significant ground water contamination problem reported by Colorado and Arizona.

Landfills have long been used to dispose of wastes and, in the past, little regard was given to the potential for ground water contamination in site selection. Landfills were generally sited on land considered to have no other uses. Unlined abandoned sand and gravel pits, old strip mines, marshlands, and sinkholes were often used. In many instances, the water table was at, or very near the ground surface, and the potential for ground water contamination was high. Not surprisingly, states consistently cite landfills as a high-priority source of ground water contamination. Generally, the greatest concern is associated with practices or activities that occurred prior to establishment of construction standards for landfills. Present-day landfills are now required to adhere to stringent construction and ground water monitoring standards.

Generally, discharges to surface impoundments such as pits, ponds, and lagoons are underregulated. In Indiana, many surface impoundments neither discharge to surface water nor have designed outfalls; as a consequence, they have the potential to leach metals, volatile organic compounds, and semivolatile organic compounds to ground water. In Colorado, wells located downgradient from tailings ponds or cyanide heaps associated with mining operations often exhibit high concentrations of metals. Arizona also identified surface impoundments and leach fields as significant sources of volatile organic compounds.

Class V injection wells include shallow wastewater disposal wells, septic systems, storm water drains, and agricultural drainage systems. Class V injection wells are used to dispose of wastewaters directly into the ground. Because they are not designed to treat the wastewaters released through them, ground water supplies can become contaminated. The large number and diversity of Class V injection wells pose a significant potential threat to ground water. The state of Indiana indicated that they are targeting these installations for further legislative controls.

Agricultural Practices

Agricultural practices that have the potential to contaminate ground water include

- Animal feedlots
- Fertilizer and pesticide applications
- Irrigation practices
- Agricultural chemical facilities
- Drainage wells.

Ground water contamination can be a result of routine applications, spillage, or misuse of pesticides and fertilizers during handling and storage, manure storage/ spreading, improper storage of chemicals, and irrigation return drains serving as a direct conduit to ground water. Fields with over-applied and/or misapplied fertilizers and pesticides can introduce nitrogen, pesticides, cadmium, chloride, mercury, and selenium into the ground water. States report that agricultural practices continue to be a major source of ground water contamination.

Animal feeding operations can pose a number of risks to water quality and public health, mainly because of the amount of animal manure and wastewater they generate. Animal feedlots often have impoundments from which wastes may infiltrate to ground water. Livestock waste is a source of nitrate, bacteria, total dissolved solids, and sulfates.

Livestock is an integral component of many states' economies. As a consequence, concentrated animal feeding operations occur in many states. The high concentration of manure in feedlot areas causes confined animal feedlots to be a concern for contributing to ground water contamination.

Shallow unconfined aquifers in many states have become contaminated from the application of fertilizer. Crop fertilization is the most important agricultural practice contributing nitrate to the environment. Nitrate is considered by many to be the most widespread ground water contaminant. To help combat the problems associated with the overuse of fertilizers, the U.S. Department of Agriculture's Natural Resources Conservation Service assists crop producers in developing nutrient management plans.

Human-induced salinity also occurs in agricultural regions where irrigation is used extensively. Irrigation water continually flushes nitrate-related compounds from fertilizers into the shallow aquifers along with high levels of chloride, sodium, and other metals, thereby increasing the salinity of the underlying aquifers.

Risk of Multiple Contaminants

In a recent study by the University of Wisconsin-Madison, researchers noted that common mixtures of pesticides and fertilizers can have biological effects at the current concentrations measured in ground water. Specifically, the combination of aldicarb, atrazine, and nitrate, which are the most common contaminants detected in ground water, can influence the immune and endocrine systems as well as affect neurological health. Changes in the ability to learn and in patterns of aggression were observed. Effects are most noticeable when a single pesticide is combined with nitrate fertilizer. Research shows that children and developing fetuses are most at risk. EPA is developing an approach to deal with mixtures under the cumulative risk policy. The initial step is to deal with mixtures on a case-by-case basis beginning with the organophosphate pesticides as a group. Dealing with mixtures of chemicals under the Food Quality Protection Act and Safe Drinking Water Act will continue to be a challenge in the future.*

*Porter et al. 1999. *Toxicology and Industrial Health* 15, 133-150.

Metals in the Environment

Metals may be present in industrial and commercial process waste streams. These metals tend to be persistent with little to no potential for degradation. Predicting their mobility and toxicity is complex due to the large number of chemical reactions that can affect their behavior. The scientific community is only just now beginning to unravel the intricacies involved in predicting metals behavior in the environment.

Pesticide use and application practices are of great concern. The primary routes of pesticide transport to ground water are through leaching or by spills and direct infiltration through drainage controls. Pesticide infiltration is generally greatest when rainfall is intense and occurs shortly after the pesticide is applied. Within sensitive areas, ground water monitoring has shown fairly widespread detections of pesticides, specifically the pesticide atrazine. Many states are developing or have developed specific management plans to better control pesticide application rates and frequency to lessen the impacts on the resource.

Industrial Practices

Raw materials and waste handling in industrial processes can pose a threat to ground water quality. States noted that industrial facilities, hazardous waste generators, and manufacturing/repair shops all present the potential for releases. Storage of raw materials at the facility are a problem if the materials are stored improperly and leaks or spills occur. Examples include chemical drums that are carelessly stacked or damaged and/or dry materials that are exposed to rainfall. Material transport and transfer operations at these facilities can also be a cause for concern. If a tanker operator is careless when delivering raw materials to a facility, spills may occur.

The most common contaminants are metals, volatile organic compounds, semivolatile organic compounds, and petroleum compounds. States reported releases of each of these contaminant types in association with industrial practices in their 1998 305(b) reports as both a current and potential threat to ground water quality.

Cyanide spills associated with ore processing continue to affect ground water quality in Montana. Ground water contamination extending beyond mine properties has occurred at nine ore processing facilities. Water supplies have been affected by at least three spills. Thirty-eight ore processors are known to have used cyanide at some point during their operation, and, of these facilities, four remain active. Cyanide will continue to affect the quality of Montana's ground water in these mining areas from past releases as well as from the potential threat of future accidental releases.

Spills are a source of grave concern among states. The state of Indiana reported that about 50 spills occur per week. In 1996, 41 million gallons of chemicals, industrial wastes, and agricultural products were spilled in Indiana. Montana reports an average of 300 accidental spills each year. On average, approximately 15 of these spills require extensive cleanup and followup ground water monitoring. One of these was the 1995 derailment of railroad tanker cars in the Helena rail yard that threatened to contaminate ground water with 17,400 gallons of fuel oil. Followup monitoring demonstrated that rapid response actions had prevented the majority of the contaminants from reaching local aquifers.

Volatile organic compounds associated with solvent spills and leaks from electronics, aerospace, and military facilities that use these chemicals as degreasing agents were identified by Arizona as major sources of ground water contamination. South Carolina determined that accidental spills and leaks are the second most common source of ground water contamination, and, as in Arizona, these releases can usually be associated with petroleum-based products attributed to machinery maintenance or manufacturing. Spills will never become entirely preventable, but industry, local governments, and states are cooperating to control spills when they do occur so that the impact to the environment is minimized

Development of new technologies and new products to replace organic solvents is continuing. For example, organic biodegradable solvents derived from plants are being developed for large-scale industrial applications. Environmentally responsible dry cleaning technologies are being developed that eliminate the need for perchloroethylene. Legislation is being considered in New York and by other local governments and states that would ban the use of perchloroethylene by the dry cleaning industry.

State Overview of Contaminant Sources

States inventory the types and numbers of contaminant sources having the potential to impact ground water quality in selected aquifers. This type of information serves three purposes:

- To identify contaminant sources with the greatest potential to impact ground water quality based on sheer number of sites
- To determine the number of sites actually having impacted ground water resources
- To determine the remedial actions being taken to address the contamination and the degree of success.

For 1998, 26 states reported contaminant source information for specific aquifers. Table 1 summarizes contaminant source information for those 26 states. Many states do not yet track this type of information in an easily accessible format.

As shown in Table 1, underground storage tanks (USTs) represent the highest number of potential sources of ground water contamination. These findings are consistent with data reported during the 1996 305(b) cycle. Over 85,000 UST sites were reported in 72 hydrogeologic settings in 22 states. Of these tanks, 57% were characterized by confirmed contaminant releases to the environment and 18% had releases that adversely affected ground water quality. These sites are slowly being cleaned up and restored. Nearly 21,500 (25%) of these sites have been remediated as of late 1998. Much of the money that supports cleanup operations is provided by State Underground Tank Remediation Funds. Eighteen states reported that they have fully established Remediation Funds.

States ranked underground injection sites as second on the list of potential sources of contamination. More than 31,000 underground injection sites exist in the 72 settings evaluated. The percent with confirmed ground water contamination is less than 5%, suggesting that underground injection sites are less of a threat than leaking USTs.

State sites include unregulated chemical spills or historic sites for which there is no responsible party. These sites are not covered by an EPA regulatory program. State sites accounted for over 12,000 sites present in 34 hydrogeologic settings. Of these sites, over 50% have confirmed contaminant releases and over 25% have confirmed ground water impacts.

For each of the sources listed in Table 1, states attempted to identify the types of contaminants most likely to be present. Although contaminants ranged from asbestos to radionuclides, the most frequently cited contaminants were

- Volatile organic compounds
- Petroleum compounds
- Metals
- Pesticides
- Nitrate.

Volatile organic compounds and petroleum compounds were each cited as contaminants of concern in 60% of the hydrogeologic settings for which states reported data. Metals were measured in ground water collected from 52% of the hydrogeologic settings. Pesticides and nitrate were cited 31% and 22% of the time, respectively.

Table 1. Summary of Contaminant Source Type and Number

Source Type	Number of States Reporting Information	Number of Aquifers or Hydrogeologic Settings for Which Information Was Reported	Total Sites	Number of Sites with Confirmed Releases		Number of Sites with Confirmed Ground Water Contamination	
				Number	Percent of Total	Number	Percent of Total
LUST	22	72	85,067	48,320	57	15,436	18
Underground Injection	17	72	31,480	1,313	4	172	<1
State Sites	17	34	12,202	6,199	51	3,139	26
DOD/DOE	17	54	8,705	4,470	51	286	3
CERCLA (non-NPL)	19	59	3,506	1,381	39	802	23
RCRA Corrective Action	19	50	2,696	538	20	267	10
Nonpoint Sources	8	29	2,030	44	2	31	<2
Landfills	6	26	1,356	110	8	110	8
NPL	22	66	307	275	90	249	81

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
DOD/DOE = Department of Defense/Department of Energy.
LUST = Leaking Underground Storage Tank.
NPL = National Priority List.
RCRA = Resource Conservation and Recovery Act.
— = Not available.

Ground Water Assessments

The 1998 305(b) reporting cycle was the second cycle for which states reported quantitative ground water monitoring data on an aquifer-specific basis. Data reporting increased in uniformity in 1998 as states became familiar with the revised Ground Water Guidelines and began developing methodologies to report the data in the format requested. Increased consistency in the way data were submitted allowed for more meaningful comparisons of reported data.

Thirty-one states reported ground water monitoring data that were used in this assessment. Ten states and tribes reported ground water monitoring data for the first time in 1998. Additional data from 14 states were also received, but the data were not compatible with the 305(b) data format and could not be used in the national summary. Figure 8 shows the states that submitted ground water data for the 1998 305(b) reporting cycle.

States that achieved full state coverage in 1996 reported their most recent monitoring results for 1998. States that implemented rotating monitoring plans reported data for additional aquifers within the state.

Texas is an example of a state that uses a rotating monitoring design. The Texas Groundwater Protection Committee is the

Hydrogeologic Settings

This term describes the geologic-related ground water and surface water factors that affect and control ground water movement into an area. Factors—such as depth to ground water, soil type, and the amount of recharge—can be used to map areas with common characteristics. It is possible then to make generalizations about the vulnerability of the setting to potential contaminants.

Aller et al. 1987. *DRASTIC — A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings.* EPA/600/2-87/035. U.S. Environmental Protection Agency.

Number of Sites with Active Remediation		Number of Sites with Cleanup Completed	
Number	Percent of Total	Number	Percent of Total
3,044	4	21,438	25
61	<1	452	<2
753	6	3,242	27
1,717	20	1,937	22
229	7	316	9
95	4	67	3
5	<1	3	<1
2	<1	—	—
83	27	33	11

coordinating entity for Texas ground water issues. The Texas Water Development Board performs ambient ground water monitoring on a selected number of Texas aquifers each year so that all major and minor aquifers of the state are monitored within a 5-year period.

Major and minor aquifers underlie approximately 76% of Texas' 267,338 square miles of land surface. Major aquifers produce large quantities of water in a larger area of the state. Minor aquifers produce significant quantities of water within smaller geographic areas or small quantities in large geographic areas. Nine major aquifers and twenty minor aquifers have been delineated within the state.

Approximately 4,200 domestic and agricultural water wells are sampled as part of this 5-year program.

Figure 8

States Reporting Ground Water Data

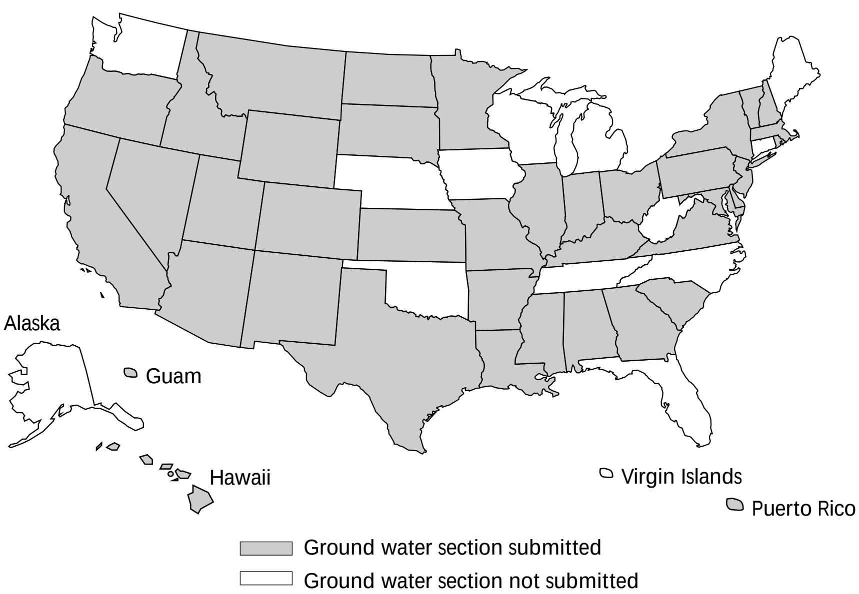


Figure 9 illustrates the aquifers assessed during the first three monitoring cycles. The remaining Texas aquifers will be assessed for 2000 and 2001.

Texas' goal is to completely assess all major and minor aquifers every 5 years. After this first 5-year cycle is complete, a historical analysis of ambient ground water quality will begin as the state repeats the cycle.

Hawaii provides yet another plan for implementing statewide ground water assessment. Hawaii designed a three-phased plan. Phase I uses existing information from the Department of Health aquifer research program and wellhead protection assessments. These data are compared with ground water contamination maps of detected organic chemical contamination in the state. Together these data provide an overlay of the location of aquifers in the state, locations where contaminants have been detected, and specific aquifer/wellhead areas that have been assessed for vulnerability to contamination. Phase I assessments were submitted as part of the 1998 305(b) cycle.

Phase II assessments will be reported as part of the 2000 and 2002 305(b) cycles. They will be based on data from the Hawaii Source Water Assessment Program (HISWAP). Phase II information will provide comprehensive data on public drinking water sources and will identify

- Source water protection areas
- Sources of contamination
- Susceptibility of source water to contamination.

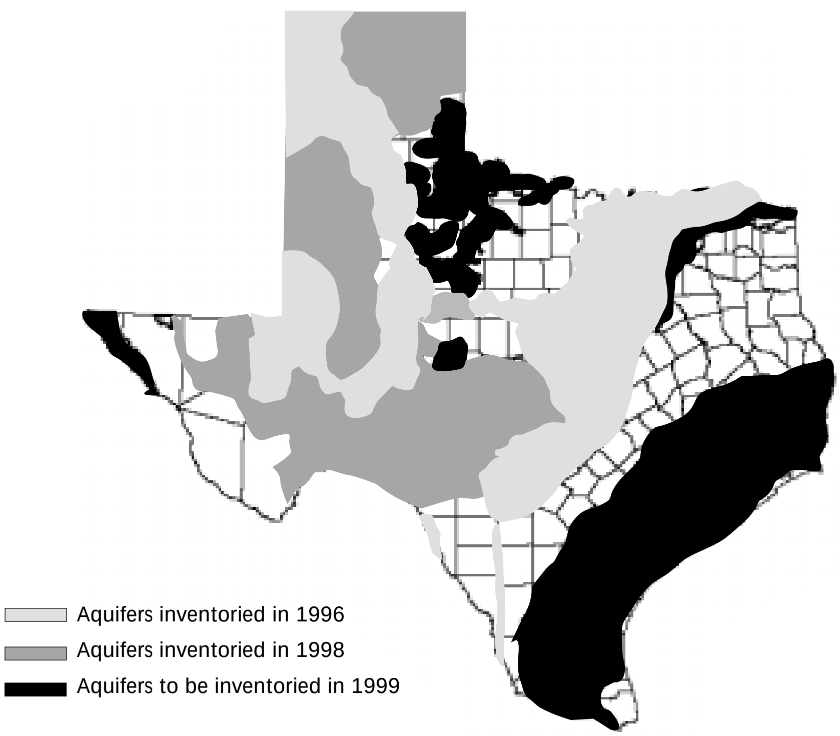
Phase III assessment will include all completed HISWAP assessments and any ambient ground water data collected and/or analyzed. Phase III will produce a comprehensive database of public drinking water sources and ambient ground water data. Implementation of this phase will depend on pending policy and budget decisions.

Ground Water Quality Data

For the 1998 305(b) cycle, states assessed ground water quality using three primary sources of data: ambient ground water monitoring data, unfinished water quality data, and finished water quality data (Figure 10). Furthermore, states reported results for a smaller suite of analytes relative to the 1996 305(b) cycle, focusing primarily on volatile organic compounds, semivolatile organic compounds, and nitrate. Emphasis on these three parameter groupings is warranted because the presence of

Figure 9

Texas Water Quality Inventory



Framework for Compiling State Data

Assessment of ground water quality under the 305(b) program is evolving, and many changes have been implemented over the past decade to develop an accurate representation of our nation's ground water quality. One of the most significant changes was the request that states begin reporting ground water monitoring data for specific aquifers or hydrogeologic settings within the state. As the states began reporting monitoring data for multiple hydrogeologic settings, EPA responded by developing a database to compile and maintain the large volume of ambient ground water quality data being reported as part of the 305(b) program. This database provides a framework for state-reported ground water quality data.

Currently, the dataset contains ground water monitoring data for 243 hydrogeologic settings, representing data reported by states for the 1996 and 1998 305(b) cycles. Obviously, this set of data provides limited national coverage, and only a limited assessment of ground water quality on a national basis is possible at this time. However, a framework for reporting and compiling data on a biennial basis has been established, and, as states report new data with each successive 305(b) cycle, the data set will mature. With continuing efforts, an accurate and representative assessment of our nation's ground water resources should emerge.

Tribal 305(b) Submittals

Four Native American tribes submitted 305(b) water quality reports in 1998. They are

- La Jolla Band of Indians of Pauma Valley, California
- Twenty-Nine Palms Band of Mission Indians of Coachella, California
- Torres-Martinez Desert Cahuilla Indians of Thermal, California
- Agua Caliente Band of Cahuilla Indians of Palm Springs, California.

La Jolla Band of Indians is located in the San Luis Rey River Ground Water Basin and the other three tribes are located in the Coachella Valley Groundwater Basin. The Coachella Valley Water District has undertaken extensive studies to estimate ground water production and overdraft in the Valley. Recent estimates indicate that ground water is in an overdraft situation with more water being pumped out of the Valley than is entering as recharge. Estimates of overdraft in the lower Valley range from 50,000 to 150,000 acre-feet per year. Approximately half of the overdraft is attributed to agriculture and half is attributed to municipal and recreational uses.

Anthropogenic sources of ground water contamination include agricultural chemical facilities, fertilizer applications, irrigation and drainage practices, wastepiles, deep and shallow injection wells, septic systems, underground storage tanks, and industrial facilities. The overdraft situation in the Valley causes higher hydraulic gradients and increases the potential for ground water contaminants to affect ground water resources. One very common contaminant that is detected in ground water on the reservations is nitrate. All four tribes assessed ground water quality using nitrate as an indicator parameter.

Natural sources of contamination also impact ground water quality. Fluoride-bearing minerals present in the aquifer substrate contribute high levels of fluoride to the ground water. Arsenic and radionuclides may also be present in ground water through leaching of natural sources. All four tribes assessed ground water quality for fluoride. Three of the four tribes assessed arsenic and either gross alpha or uranium concentrations as well. Arsenic and radionuclide data were not available to the La Jolla Band of Indians.

Ground water assessments were conducted by reviewing historic water quality data of operating wells, monitoring the quality of water from springs, and collecting supplemental ground water quality data in the vicinity of the reservations. The number of wells sampled ranged from five wells (La Jolla Band of Indians) to 47 wells (Agua Caliente Band of Cahuilla Indians). Common parameters monitored on the reservations included nitrate, arsenic, fluoride, radionuclides, volatile organic compounds, and semivolatile organic compounds. Monitoring data were compared to federal drinking water standards to assess whether the ground water met beneficial uses such as drinking water, agricultural supply, and/or industrial supply.

Nitrate is present at detectable concentrations in ground water collected from all four reservations. However, the maximum contaminant level, or MCL, for nitrate is rarely exceeded. Fluoride and arsenic are also present at detectable concentrations. Radionuclides are measured at concentrations that are generally representative of background conditions.

Fluoride was the most frequently detected constituent at concentrations exceeding the drinking water standard in ground water collected from the 29 Palms Reservation. Fluoride was measured at concentrations exceeding one-half the drinking water standard in ground water collected from the Torres-Martinez Reservation. In contrast, nearly 30%, or 20 out of 71 samples, exceeded the MCL for arsenic in ground water collected from the Torres-Martinez Reservation. MCL exceedances were rarely observed in ground water collected from the Agua Caliente Reservation. Of the three tribes that tested for volatile organic compounds or semivolatile organic compounds, no concentrations exceeded the MCL. Hence, although some water quality issues may exist on the reservations, these water quality impacts do not seem to be caused by anthropogenic sources. Rather, most of the observed MCL exceedances can be traced back to natural sources.

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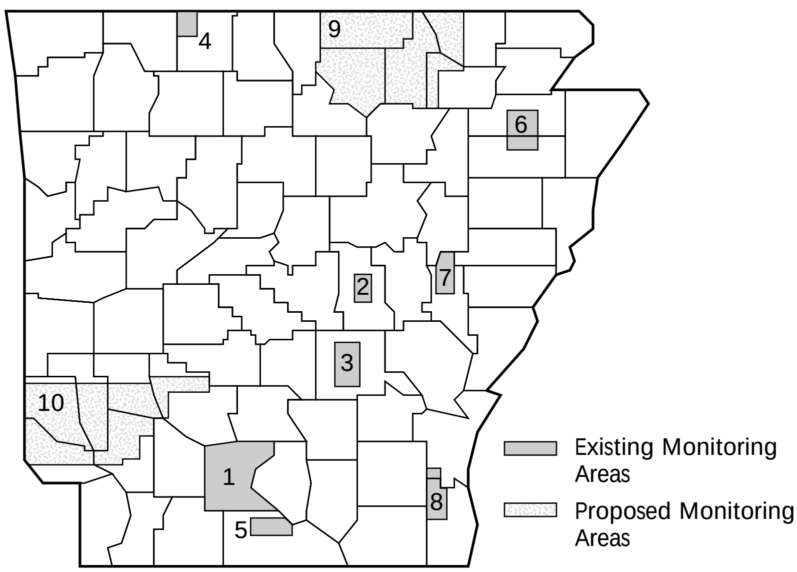
Different Types of Monitoring Settings

Thirty-one states reported data summarizing ground water quality. In total, data were reported for 146 aquifers or other hydrogeologic settings for the 1998 305(b) cycle. States that were unable to report ground water quality data for specific aquifers assessed ground water quality using a number of different hydrogeologic settings, including statewide summaries, counties, watersheds, basins, and sites or areas chosen for specific monitoring purposes. A brief description of several ground water assessment methods and their rationale is presented.



Arkansas Ambient Ground Water Monitoring Program

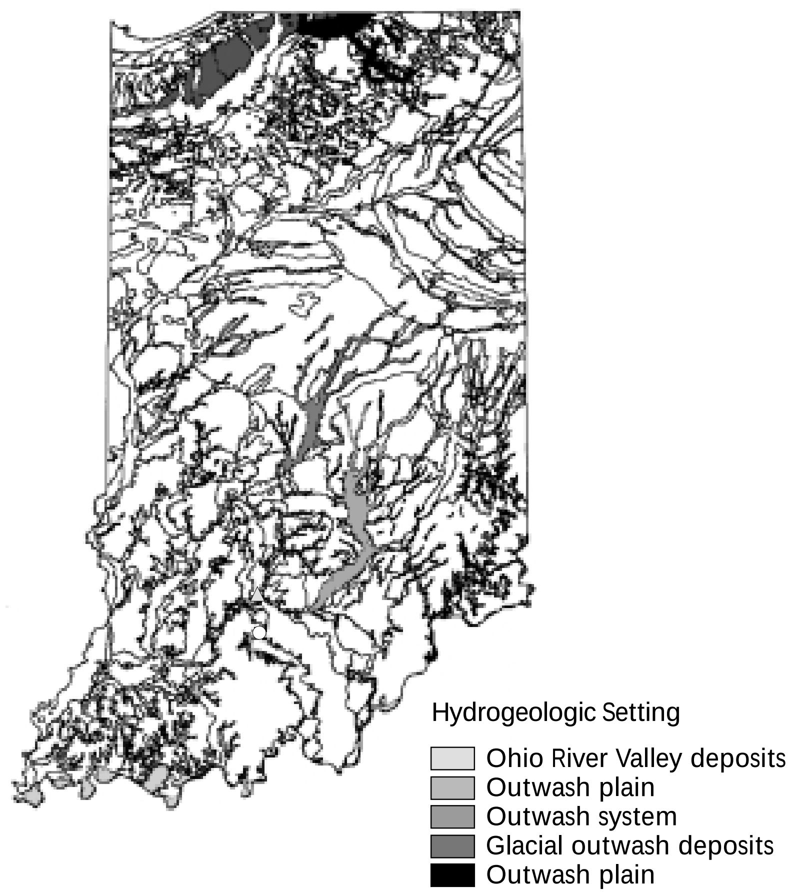
Existing monitoring areas include Ouachita (1), Lonoke (2), Pine Bluff (3), Omaha (4), El Dorado (5), Jonesboro (6), Brinkley (7), and Chicot (8). Expansion areas will include Hardy (9) and Athens Plateau (10).

Arkansas – Ambient Ground Water Monitoring Program

The Arkansas Department of Pollution Control and Ecology began its Ambient Ground Water Monitoring Program in 1986 to monitor overall ground water quality in the state. The Program currently consists of eight active monitoring areas and two proposed areas selected to evaluate potential impacts from multiple land uses (see figure). The areas are in different counties covering the diverse geologic, hydrologic, and economic regimes within the state. One area is characterized by the largest community using ground water to meet all of its needs. An objective of the monitoring program is to monitor water quality that is affected by public and commercial well use. For the 1998 305(b) cycle, Arkansas reported their most recent round of results for the eight active monitoring areas.

Indiana – Hydrogeologic Settings

Indiana developed a system that allows for data to be analyzed according to similar surface and subsurface environments. To interpret the ground water sensitivity to contamination, the analysis considers the composition, thickness, and geometry of the aquifers; variability of the confining units; surface and ground water interactions; and recharge/discharge relationships (see figure). For the 1998 305(b) cycle, Indiana selected hydrogeologic settings that were vulnerable to contamination and contain large populated areas (i.e., areas of greatest ground water demand). These settings were principally outwash deposits or fans of glacial origin.



Map of Hydrogeologic Settings

Alabama – Cumberland Plateau Ground Water Province

Alabama divided the state into physiographic provinces and is assessing ground water quality in aquifers in different provinces with each successive 305(b) cycle. Ground water quality in the Tuscumbia Fort Payne Aquifer outcrop area in the Highland Rim Province

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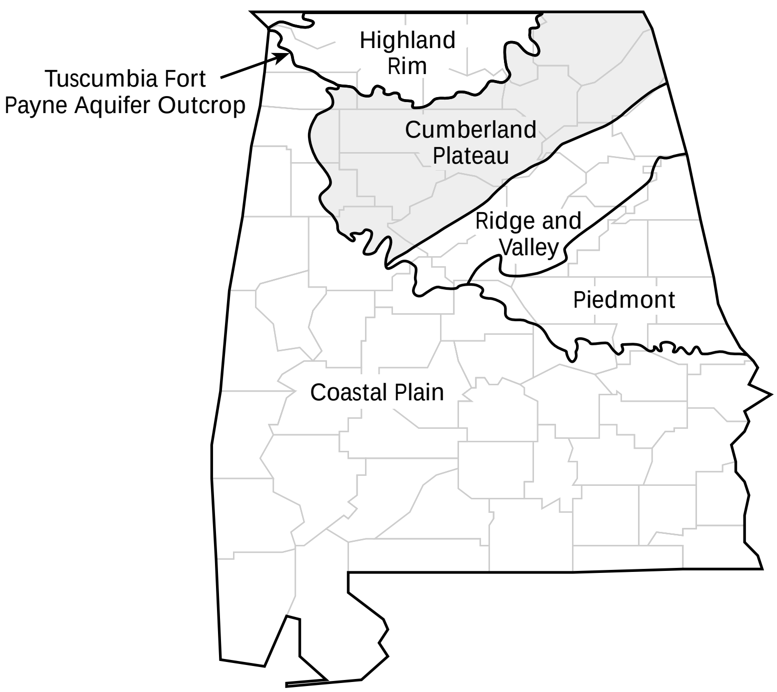
was evaluated in 1996. Alabama provided ground water quality data for the Cumberland Plateau Ground Water Province for 1998 (see figure). This area includes all or parts of 13 counties in north Alabama that are underlain by three major aquifer outcrop areas. The aquifers outcropping include the Pottsville Aquifer, the Tuscumbia-Fort Payne Aquifer, and those aquifers of Cambrian-Ordovician age. The shallow aquifers of the Cumberland Plateau Ground Water Province are considered vulnerable to contamination from surface sources through fractures and sinkholes that provide direct recharge to the subsurface. Some of these aquifers are also highly vulnerable to contamination through karst features that provide direct access from the surface into the aquifer.



Alabama Physiographic Provinces

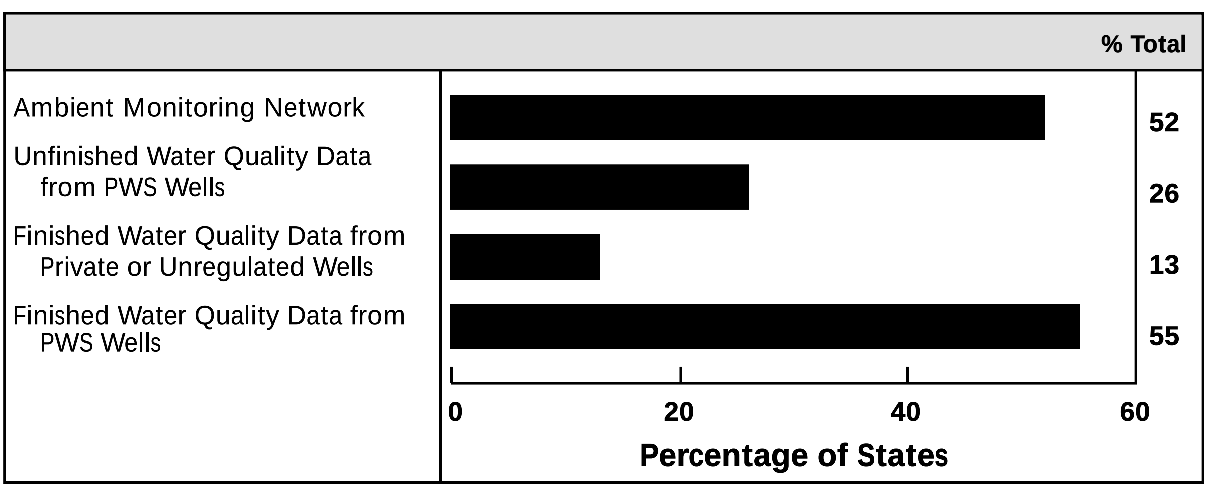
manufactured compounds (i.e., the volatile organic compounds and semivolatile organic compounds) in ground water is a definitive indication of contamination from human sources. Even if only limited data are available for assessing ground water quality, the presence of VOC and SVOCs is of serious concern. The presence of nitrate at concentrations exceeding background levels is another sign of human impacts to ground water quality. In fact, states indicated that they used nitrate as an "indicator" parameter of water quality impacts, and all 31 states reported nitrate data.

States also reported monitoring data for an "others" category. This usually referenced inorganic and/or metallic contaminants. Inorganic constituents generally referred to water quality parameters that were more reflective of natural background conditions than adverse impacts to ground water quality resulting from human activities. Some examples include sodium, calcium, magnesium, potassium, bicarbonate, fluoride, and chloride. In contrast, elevated concentrations of some metals can be a strong indication of water quality impacts resulting from human activities. Metals that reflect human activities include barium, arsenic, mercury, cadmium, zinc, lead, selenium, copper, chromium, silver, and nickel.

Tables 2 through 6 present state data for nitrate, VOCs, SVOCs, pesticides, and metals. In most cases, the reported data represent average concentration values for the monitoring period. However, some states reported results based on the maximum concentration detected in wells during the monitoring period. It is important to remember that the aquifer monitoring data reported by states represent different sources, often with different monitoring purposes, and care must be taken in making data

Figure 10

Sources of Ground Water Monitoring Data



Note: Percentage based on a total of 31 states submitting data. Some states used multiple data sources.

comparisons. Monitoring data most closely approximating actual ground water conditions (e.g., untreated ground water) are given special consideration in these assessments.

States reported aquifer monitoring data for nitrate more frequently than for any other parameter or parameter group. Nitrate is well suited for use as an indicator parameter. Its presence in ground water systems is indicative of human activities and it can be detected at relatively low concentrations through the use of standard, reliable, and relatively inexpensive analytical methodologies.

Table 2 presents aquifer monitoring data for nitrate for the 1998 305(b) reporting cycle. With the exception of untreated water quality data from public water supply (PWS) wells, the maximum contaminant level (MCL) of 10 mg/L was exceeded in at least 40% of the hydrogeologic settings for which states reported nitrate data. However, although elevated nitrate levels were documented by states in ground water, the percentage of wells that were impacted by nitrate levels in excess of the MCL was less than 5% for ambient ground water monitoring networks and less than 1% for drinking water sources. The percentage of wells impacted by nitrate was higher in the two special studies reported by states. However, these studies were specifically designed to monitor land use effects with the potential to contribute nitrate to the environment, so their data may be skewed.

Tables 3 through 5 provide summary information for VOCs, SVOCs, and pesticides. States reported ground water monitoring data for VOCs more frequently than for either SVOCs or pesticides.

Table 2. Monitoring Results for Nitrates

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	16	10	95	38 (40%)	7,555	307	55 out of 114	8
Unfinished Water Quality Data from PWS Wells	8	0	20	0	538	0	0 out of 173	0
Unfinished Water Quality Data from Private or Unregulated Wells	4	3	4	3 (75%)	12,180	62	48 out of 3,165	21
Finished Water Quality Data from PWS wells	17	10	57	26 (46%)	32,936	379	284 out of 3,057	14
Special Studies	2	2	6	4 (67%)	424	68	33 out of 96	17

MCL = Maximum contaminant level.
PWS = Public water supply.

Approximately half of the reporting states indicated that VOCs had exceeded MCLs in ground water. Approximately 25% of the hydrogeologic settings were characterized by MCL exceedances of VOCs in ambient ground water. However, only 6% of the wells used to assess ambient ground water quality were characterized by MCL exceedances of VOCs. The greatest percentage of MCL exceedances (9%) was observed in private and unregulated wells.

Four states reported data for pesticides in ambient ground water. Of these four states, two states reported the presence of pesticides at concentrations exceeding MCLs. Levels of pesticides exceeding MCLs impacted 17% of the hydrogeologic settings and 2% of the wells monitoring ambient ground water conditions. Semivolatile organic compounds were rarely measured in ground water at concentrations exceeding MCLs.

Forty percent of the hydrogeologic settings for which states reported ambient ground water monitoring data were affected by metal concentrations that exceeded MCL values. The percentage of hydrogeologic settings affected by elevated metal concentrations was even higher for untreated and finished water collected from PWS wells. Again, although the number of settings is relatively high, the percentage of wells that are characterized by MCL exceedances is relatively low with approximately only 1% of the wells monitoring ambient ground water conditions being impacted. In contrast, 12% of the wells supplying untreated water quality data from PWS were impacted.

Table 3. Monitoring Results for Volatile Organic Compounds

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceed-ances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceed-ances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	9	4	55	13 (24%)	3,644	214 (6%)	143 out of 441	16
Unfinished Water Quality Data from PWS Wells	6	3	18	3 (17%)	404	9	6 out of 11	3
Unfinished Water Quality Data from Private or Unregulated Wells	1	1	2	1 (50%)	23	2 (9%)	2 out of 19	2
Finished Water Quality Data from PWS wells	17	9	60	13 (22%)	17,021	83	47 out of 1,484	6
Special Studies	1	0	1	0	0	0	0	0

MCL = Maximum contaminant level.
PWS = Public water supply.

Examples of State Assessments

Although very positive strides were made in assessing ground water quality in 1998, ground water data collection under Section 305(b) is still too immature to provide national assessments. Despite the lack of national coverage, states have demonstrated strong assessment capabilities. Following are descriptions of two states' assessments that may be useful to other states in designing and implementing monitoring programs.

Idaho

Idaho is one of the top five states in the nation with respect to the volume of ground water used to meet the needs of its population. Idahoans use an average of 9 billion gallons of ground water daily. Sixty percent of this water is used for crop irrigation and stock animals, 36% is used by industry, and 3% to 4% is used for drinking water. Even though the volume of ground water used as drinking water is relatively small in comparison to the total ground water used, more than 90% of the total population in Idaho relies on ground water for drinking water supply.

To characterize and protect this valuable resource, Idaho developed a monitoring approach that includes a statewide ambient ground water quality monitoring network integrated with regional and local monitoring. The statewide monitoring network is used to

- Characterize ground water quality conditions
- Identify trends in ground water quality

Table 4. Monitoring Results for Semivolatile Organic Compounds

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceed-ances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceed-ances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	6	1	18	1	357	1	1 out of 81	1
Unfinished Water Quality Data from PWS Wells	7	1	16	1	338	1	1 out of 26	1
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	2	0	0 out of 2	0
Finished Water Quality Data from PWS wells	15	2	36	2	12,518	8	7 out of 193	4
Special Studies	—	—	—	—	—	—	—	—

MCL = Maximum contaminant level.
PWS = Public water supply.
— = Not applicable.

■ Identify existing and emerging ground water quality concerns in Idaho's major aquifers.

The monitoring network consists of a statistically designed set of more than 1,500 sites (wells and springs) used for domestic, irrigation, public water supply, and stock purposes. These sites are sampled on a rotational basis so that most locations are sampled at least once every 4-year period, with some wells being sampled yearly. Ground water samples are analyzed for many of the analytes monitored under the Safe Drinking Water Act. All samples are analyzed for volatile organic compounds, nutrients, fecal coliform, trace elements, radionuclides, pesticides, and major ions.

Regional and local monitoring can be used to (1) identify and delineate ground water contamination problems that are smaller in scale and may not be immediately evident on the larger scale of the statewide monitoring effort, (2) determine the areal extent of ground water contamination to ensure that beneficial uses are protected, (3) determine the effectiveness of remediation activities and best management practices, and (4) provide information, direction, and prioritization to state ground water quality programs. Thus far, regional or local monitoring projects have been used to further characterize many of the aquifers in Idaho, especially those where ground water quality has been identified as a concern.

Idaho has a very diverse geology and there are numerous aquifers and aquifer types throughout the state. Seventy major flow systems, with each flow system comprising one or more major aquifers, have been identified and combined into 22 hydrogeologic areas. Each area represents

Table 5. Monitoring Results for Pesticides

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	4	2	18	3 (17%)	758	16 (2%)	8 out of 25	5
Unfinished Water Quality Data from PWS Wells	1	1	7	1	46	2	2 out of 3	2
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	27	0	0 out of 27	0
Finished Water Quality Data from PWS wells	1	1	1	1	8	1	1 out of 8	1
Special Studies	2	1	4	2	328	2	1 out of 96	1

MCL = Maximum contaminant level.
PWS = Public water supply.

geologically similar areas and generally encompasses one or several of the 70 major ground water flow systems. Figure 11 shows the hydrogeologic area boundaries and the major flow systems within Idaho.

For ground water quality management purposes, including implementation of regional and local monitoring, areas or flow systems are usually further broken down to a single aquifer or portion of an aquifer that focuses on a specific priority area. These priority area boundaries are usually based on considerations such as land use, hydrogeology, ground water quality, political boundaries, wellhead (source water) protection areas, and watershed boundaries. Figure 12 illustrates some of these priority areas where there are elevated levels of nitrate. This information is being used to provide direction to various ground water quality protection programs in Idaho.

Data collected from all monitoring efforts thus far indicate that most of Idaho's ground water is both potable and safe for current beneficial uses. However, no area tested is free of contaminant concerns. At least 7% of the sites had a constituent with a concentration exceeding the Safe Drinking Water Act maximum contaminant level. Initial trend analyses indicate that, overall, nitrate concentrations increased from the first round (1991 through 1995) of sampling to the second round (1995 through 1998). Although results show that only 3% of sample sites across Idaho exceed the nitrate MCL of 10 milligrams per liter, within the nitrate priority areas (Figure 12), this value increases to about 17%.

Table 6. Monitoring Results for Metals

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	7	5	40	16 (40%)	19,636	111 (<1%)	24 out of 28	5
Unfinished Water Quality Data from PWS Wells	4	2	4	2	199	23 (12%)	20 out of 71	8
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	5	0	0 out of 5	0
Finished Water Quality Data from PWS wells	3	2	4	2	3,380	63	46 out of 1,107	16
Special Studies	1	0	2	0	63	0	0	0

MCL = Maximum contaminant level.
PWS = Public water supply.

Pennsylvania

Nearly half of the population in Pennsylvania relies on ground water for drinking water purposes, and, in some areas, ground water serves as the sole source of water. To protect its ground water resources, Pennsylvania developed a ground water monitoring system that accomplishes the following goals:

- Measures ambient ground water quality
- Provides an indication of long-term ground water quality trends resulting from land use practices
- Assesses the success or failure of land management practices.

Pennsylvania's ground water monitoring program was developed following division of the state into 478 ground water basins (Figure 13). Although the basins are not true hydrologic units, each basin considers similarities in hydrologic

Figure 11

Idaho's Hydrogeologic Subareas and Major Aquifer Flow Systems

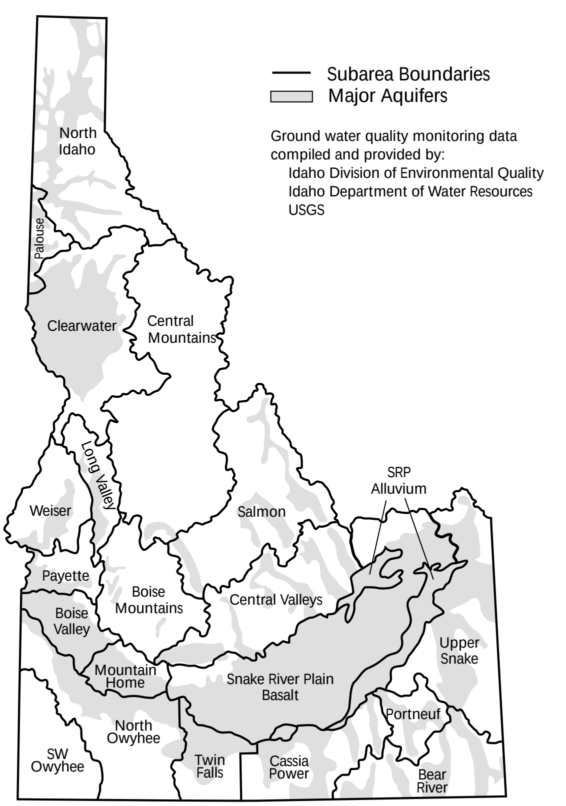
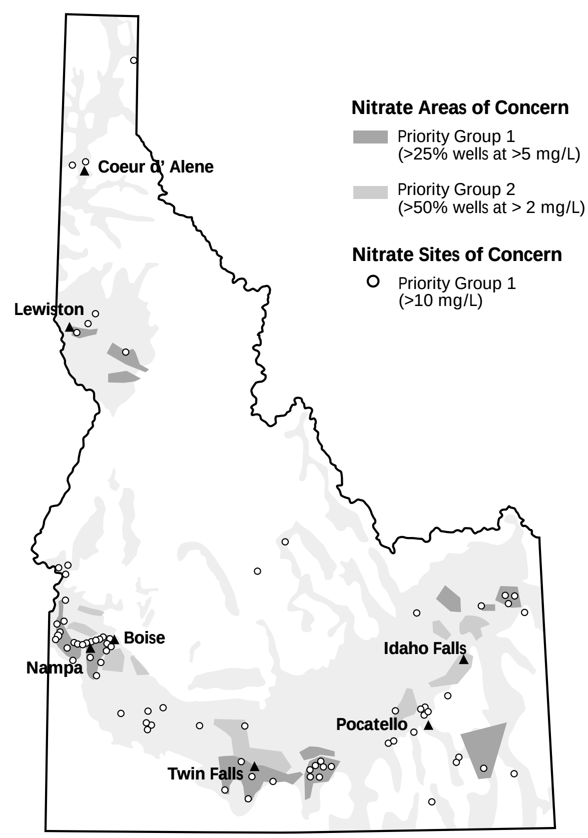


Figure 12

Ground Water Areas and Sites Impacted by Nitrate



and physical features. The basins were prioritized for monitoring purposes in 1985 according to three main factors:

- Ground water use
- Potential unmonitored sources of ground water pollution
- Environmental sensitivity.

The 50 highest-ranking basins were selected for monitoring.

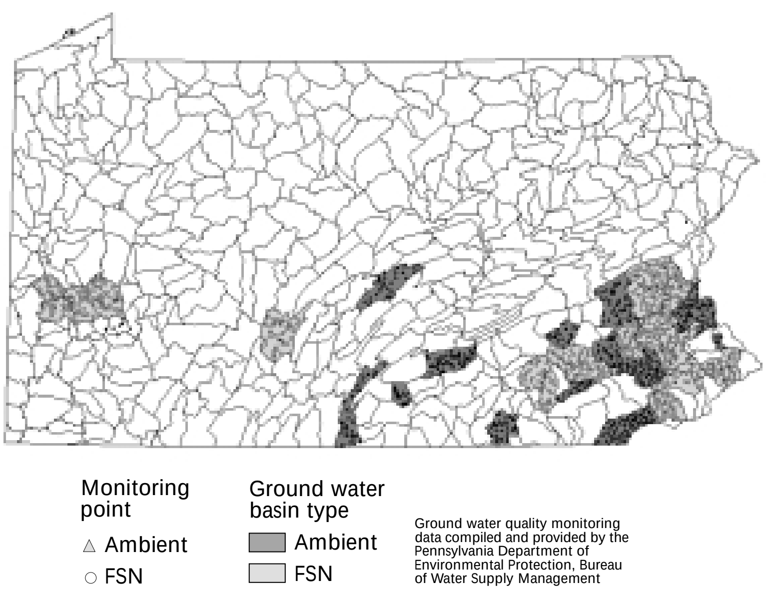
Two types of ground water monitoring are used (Figure 13). Ambient monitoring is used to collect basin-wide data for basins where little ground water quality data exist. Typically, two rounds of samples are collected in one hydrologic year. Ambient monitoring supplements other data collection efforts and provides a general picture of ground water quality in the watershed. Fixed station network monitoring is used when long-term data are required. Fixed station monitoring involves collecting two rounds of ground water samples per hydrologic year for a minimum of 5 years. Basins selected for this type of monitoring are typically high-priority basins where regional changes are occurring such as rapid urbanization or other modifications in land use or where specific water quality problems exist.

Results indicate that ground water quality in Pennsylvania is typically good. This is despite sampling in high-priority basins, which likely biases the data and presents a more negative picture of the overall ground water quality.

In spite of the overall good quality of ground water, exceedances of drinking water standards were detected. Some exceedances result from naturally elevated concentrations of substances such as iron, total dissolved solids, manganese, or low pH. However, trend analyses of nitrate, sodium, chloride, and total hardness suggest that ground water quality in Pennsylvania is undergoing some change that likely results from human activities. Sodium and chloride were two of the analytes exhibiting upward trends at more than 10% of the 478 monitoring points (Figure 14). Analytes with downward trends at more than 10% of the 478 monitoring points included pH, nitrate, magnesium, and sulfate.

Figure 13

Location of High-Priority Ambient and Fixed Station Network (FSN) Ground Water Basins and Monitoring Points



Ground water quality monitoring data compiled and provided by the Pennsylvania Department of Environmental Protection, Bureau of Water Supply Management

Exact causes of the ground water quality trends are difficult to determine. Different areas of the state are obviously under different stresses and only general inferences can be made from the data. Natural shifts in ground water quality may result from changes in precipitation trends or cycles. Downward trends in nitrate and sulfate at many monitoring points may reflect a reduction in sources of nitrate from agricultural areas (fertilizers), septic systems, and atmospheric deposition. Increasing trends in total dissolved solids (TDS), chloride, calcium, potassium, total hardness, and sodium at many monitoring points may result from increased nonpoint source pollution such as road salting and sprawling paved developments and suburbs.

Conclusions and Findings

Based on results reported by states as part of the 1998 305(b) cycle, the following are concluded:

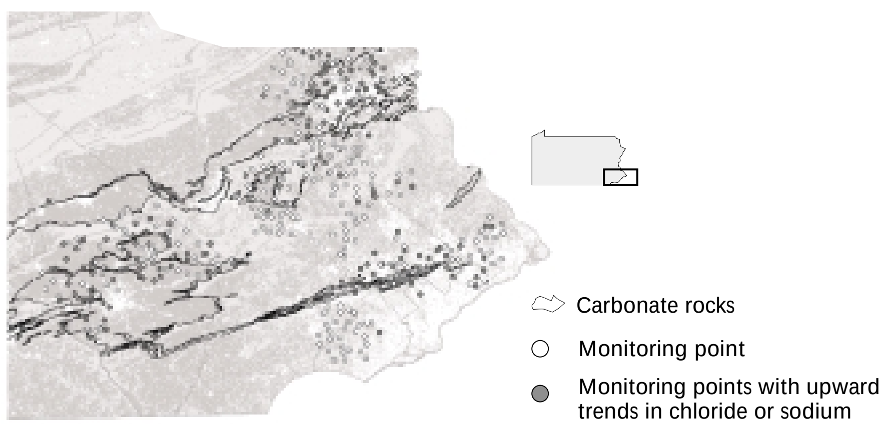
■ Ground water is an important component of our nation's fresh water resources. The use of ground water is of fundamental importance to human life and is also of significant importance to our nation's economic vitality.

■ Assessing the quality of our nation's ground water resources is no easy task. An accurate and representative assessment of ambient ground water quality requires a well-planned and well-executed monitoring plan. Although the 305(b) program is definitely moving in the direction of more and better ground water quality assessments, there is still much more that needs to be done. Coverage, both in terms of the area within a state and the number of states reporting ground water quality monitoring data, needs to be enlarged. States also need to focus on collecting ground water data that are most representative of the resource itself. Specifically, states need to rely less on finished water quality data and more on ambient ground water quality data.

■ Good quality data is essential to forming a basis for determining ground water quality. Required source water assessments under Section 1453 of the Safe Drinking Water Act should prove to be helpful in augmenting the amount

Figure 14

Monitoring Points with Upward Trends in Sodium or Chloride



Ground water quality monitoring data compiled and provided by the Pennsylvania Department of Environmental Protection, Bureau of Water Supply Management of data available and to generate good quality data that can be used to evaluate ground water quality over time.

■ The 1996 and 1998 305(b) reporting cycles represent the first time that states reported quantitative ground water quality data. One of the greatest successes was the increase in uniformity of data reported by states for 1998. There was an increase in reporting uniformity over the course of just one 305(b) cycle as states became increasingly familiar with the reporting guidelines and developed methods for obtaining and reporting the requested data.

■ Although ground water quality assessments are being performed and reported under the 305(b) program, vast differences in ground water management are apparent. Several states have implemented monitoring programs designed to characterize ground water quality and identify and address potential threats to ground water. Other states have only just begun to implement ground water protection strategies.

■ One of the most important factors in deciding state priorities concerning the assessment of ground water quality is economic constraints. Characterizing and monitoring ground water quality is expensive. Few states have the economic resources to assess ground water quality across an entire state. Therefore, states are applying different approaches to ground water protection. These approaches are based on each state's individual challenges and economic constraints. Approaches range from implementing statewide ambient ground water monitoring networks to monitoring selected aquifers on a rotating basis. States determine the approach based on the use of the resource, vulnerability to contamination, and state management decisions.

■ National coverage increased from 1996 to 1998. In the 1996 305(b) reporting cycle, states reported ground water monitoring data for a total of 162 hydrogeologic settings. In 1998, states reported data for 146 hydrogeologic settings. Data for 65 of the 146 settings described in 1998 represented the most recent monitoring results for units previously described in 1996. Thus, data were reported for 81 new hydrogeologic settings in 1998.

■ The conceptual framework for designing and implementing a ground water monitoring network is similar across the nation. The Intergovernmental Task Force on Monitoring Water Quality (ITFM) concluded that the definition and characterization of environmental monitoring settings is a crucial first step in the collection of meaningful ground water quality data. States across the nation are taking this first step and defining and characterizing hydrogeologic monitoring units. Each of the states described in detail their approach and the rationale for that approach.

■ EPA and the states need to devise more efficient ways to integrate ground water data collected through the Section 305(b) water quality inventory reports and ground water data collected from state source water assessments under Section 1453 of the SDWA.

Other monitoring data from wellhead protection delineations, source inventories, and other data collection efforts also must be integrated to increase and improve the information that is used to make determinations on the quality of ground water across the nation in the reporting requirement under Section 305(b) of the CWA.

■ Although much progress has been made in the 305(b) program to assess ground water quality, large gaps in coverage exist. The data submitted by states under the 305(b) program preclude a comprehensive representation of ground water quality in the nation at this time but, more importantly, may result in a skewed characterization of ground water quality that is more positive than actual conditions. If this is the case, problems in ground water quality may not be recognized until quality has been degraded to the point that the resource can no longer support the desired uses.

■ Based upon ground water quality data reported by states during the 1996 and 1998 305(b) cycles, ground water quality in the nation is good and continues to support the various uses of this resource.

■ Ground water contamination incidents are being reported in aquifers across the nation. Leaking underground storage tanks have consistently been reported as an important source of ground water contamination for all 305(b) cycles for which data were reported. In general, the threat from leaking underground storage tanks is due to the sheer number of tanks buried above water tables across the nation. Other important sources of ground water contamination include septic systems, landfills, hazardous waste sites, surface impoundments, industrial facilities, and agricultural land practices.

■ Petroleum chemicals, volatile organic compounds, semivolatile organic compounds, pesticides, nitrate, and metals have been measured at elevated levels in ground water across the nation. The most frequently cited contaminants of concern were volatile organic compounds and petroleum chemicals. These classes of chemicals have consistently been reported as ground water contaminants. States have also reported increasing detections of chemicals not previously measured in ground water (for example, MTBE and metals). The recent detection of these chemicals may represent emerging trends in ground water contamination.


Roger Anzzolin, Prince William County, VA

Conrad Conero, Braden Brook, Greenfield Park, NY

Ground Water Protection Programs

In their 1998 305(b) reports, states identified contaminant sources and the associated contaminants that threaten the integrity of their ground water resources. Once ground water resources have been compromised by contamination, experience has shown that it is both expensive and technologically complex to restore them to their former condition. In many cases, the resources are never fully restored. Consequently, ground water protection has become the focus of numerous state and federal programs.

The responsibility for ground water protection collectively belongs to government agencies at the federal, state, and local levels. Federal and state governments regulate ground water through laws, regulations, and policies. In many cases, state and local laws are stricter versions of federal legislation, which serves as a valuable baseline on which state and local laws can build. At the federal level, the Clean Water Act (CWA) ensures protection of surface waters designated, in part, for use as drinking water. Other environmental laws—the Safe Drinking Water Act (SDWA) (which includes the Wellhead Protection [WHP] Program, the Sole Source Aquifer [SSA] Program, and the Underground Injection Program); the Resource Conservation and Recovery Act (RCRA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)—provide authorities, financial support, and technical assistance to protect sources of drinking water, especially ground water.

This chapter presents an overview of ground water protection programs and activities that have been described by states in their 1998 305(b) reports. Federal laws and protection programs provide a framework for ground water protection for the states and are also discussed at the end of the chapter.

State Programs

States are committed to a number of activities that address existing ground water contamination problems and that prevent future impairments of the resource. These activities include enacting legislation and promulgating protection regulations, establishing plans and programs for ground water protection, and adopting and implementing protection strategies.

In their 1998 state 305(b) reports, states provided information on their ground water protection program efforts and activities. This information provides an overview of legislation, statutes, rules, and/or regulations that were in place. State reports also provide an indication of how comprehensive ground water protection activities were progressing in the state. Some states provided examples of the successful application of the state's programs, regulations, or requirements; a description of a major study or assessment; or other activities that demonstrate the state's progress toward protecting its ground water resources. Figure 15 presents a summary list of state ground water protection programs.

Ground Water Legislation

Legislation focuses on the need for program development, increased data collection, and public education activities. In many states, legislation mandates strict technical controls such as discharge permits, underground storage tank registrations, and protection standards. Legislation may be instituted in response to federal mandates and local concerns, but, in any case, states enact legislation to establish policy and associated protection programs with the purpose of restoring and maintaining ground water quality.

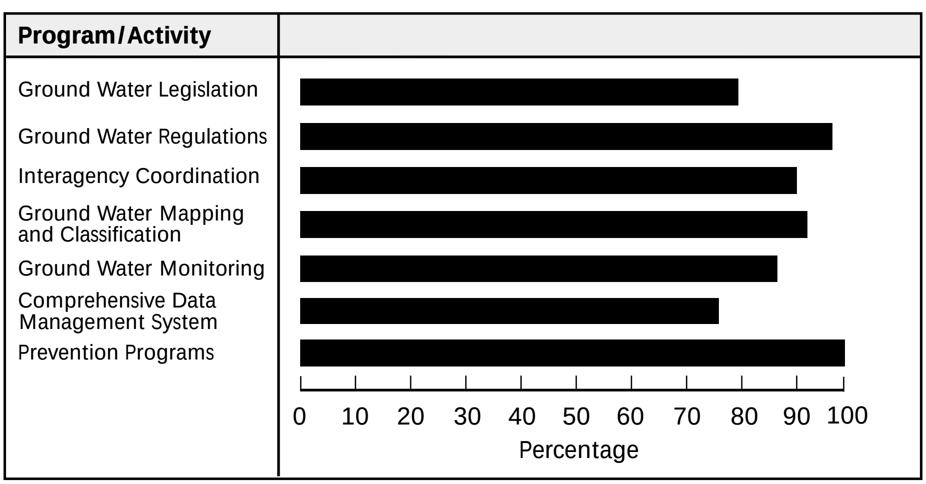
Missouri has used many conventional and widespread methods for protecting ground water. In addition there are methods that may be unique to Missouri. Two of these methods address the widespread areas of karst topography in which sinkholes or disappearing streams are prevalent and are in close connection with surface water drainage systems. The state's Cave Resources Act specifically prohibits the introduction of contaminants into sinkholes and caves for the protection of underground resources, including ground water. Sinkholes and caves provide a direct conduit for contaminants to reach shallow ground water. This law works to prevent such incidents from occurring.

In administration of the state stormwater permit program, Missouri developed a general permit for land disturbance activities that is specifically for use in the vicinity of disappearing streams and sinkholes. It contains lower limitations for sediment and other contaminants than contained in the statewide general permit that is available for other areas. Special considerations were built into the general permit for karst areas, especially for the protection of ground water, such as minimum distances from sinkholes that land disturbance is allowed and the quality of runoff water.

Rhode Island's Ground Water Protection Strategy identified the following programs to protect Rhode Island's ground water resources:

Figure 19-1

Percentage of States Having Implemented Programs



* Based on 30 states

- Ground water classification and standards

- Wellhead protection

- Management plan for pesticides and fertilizers.

The strategy includes both regulatory and nonregulatory approaches to ground water protection. A large majority of the recommended actions outlined in the strategy have been implemented. The Department of Environmental Management is now in the process of revising the strategy to reflect new data on the state's ground water resources. Once updated, the strategy will continue as a useful tool in guiding the development, refinement, and implementation of an effective comprehensive ground water protection program.

Ground Water Regulations

Federal and state governments protect ground water quality by issuing regulations to control business, agricultural, and community activities that could have an adverse impact on ground water. Regulations frequently stipulate controls for the management of specific sources of contamination. Controls include Best Management Practices (BMPs), nonpoint source controls, and discharge permits. Controls help reduce the amount of contamination that reaches the ground water generally with the goal of ultimately eliminating the sources.

Georgia's ground water regulatory programs follow an antidegradation policy under which regulated activities will not develop into significant threats to the state's ground water resources. This antidegradation policy is implemented through three principal elements:

- Pollution prevention

- Management of ground water quantity

- Monitoring of ground water quality and quantity.

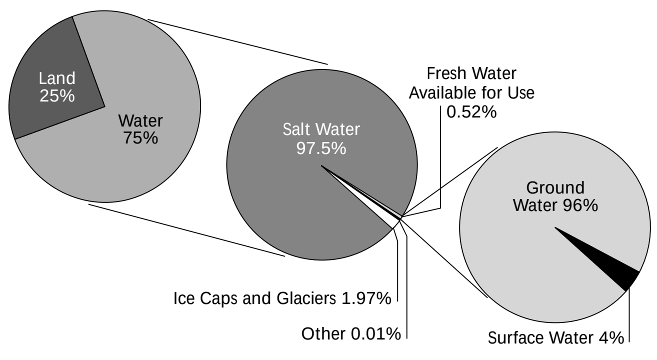
The prevention of pollution includes (1) the proper siting, construction, and operation of environmental facilities and activities through a permitting system; (2) implementation of environmental planning criteria by incorporation of land use planning by local government; (3) implementation of a Wellhead Protection Program for municipal drinking water wells; (4) detection and mitigation of existing ground water problems; (5) development of other protective standards, as appropriate, where permits are not required; and (6) education of the public to the consequences of ground water contamination and the need for ground water protection. Management of ground water quantity involves allocating the state's ground water, through a permitting system so that the resource will be available for present and future generations. Monitoring of ground water quality and quantity involves continually assessing the resource so that needed changes can be identified and corrective action implemented.

Protection of ground water from point sources of contamination in **Massachusetts** is accomplished by the Ground Water Discharge Permit Program administered by the

HIGHLIGHT HIGHLIGHT HIGHLIGHT

Ground Water: The Invisible Resource

Although 75% of the earth's surface is covered by water, less than 1% of that water is fresh water available for our use (see figure). It has been estimated that more than 95% of the world's fresh water reserves are stored in the earth as ground water. Nearly half of the world's population depends on ground water reserves to supply drinking water and other needs. Yet, the importance of ground water is generally not recognized, and, frequently, ground water resources are taken for granted. To draw attention to ground water, the United Nations General Assembly selected the theme Ground Water: The Invisible Resource to celebrate the March 22, 1998, World Day for Water.



Distribution of Water on Earth's Surface

This theme was selected in response to the United Nations' concern regarding three principal gaps in ground water management, which can have enormous implications for sustainable development of ground water resources:

- Accelerated degradation of ground water resources
- Lack of both professional and public awareness about the sustainable use and economic importance of ground water resources
- Economic implications of not resolving ground water demand and supply management.

There was a sixfold increase in global water use between 1990 and 1995. This increase is twice that of global population growth. The continuing high population growth, with consequences for food production, and justified aspirations of nations and individuals toward better living conditions will undoubtedly cause the demand for water to increase even more. In many parts of the world, surface water is under increasing pressure to meet these demands, and ground water is the only reasonable alternative water supply. Given the need to rapidly develop new water supplies, there is rarely adequate attention given to, and investment in, the maintenance, protection, and long-term sustainability of ground water.

Sustainable development has been broadly accepted as the basis for the policy of many countries of the world, and sustainable management of ground water resources is a relevant component. The condition of sustainable ground water use is that withdrawal should not exceed replenishment. To promote sustainable development of ground water resources worldwide, it is essential to

- Assess ground water resources

- Improve understanding of the ground water component within the hydrological cycle

- Conserve ground water for future generations

- Protect ground water resources from contamination.

Of these activities, assessment is of primary importance. Assessment involves determining the sources, extent, dependability, and quality of water resources on which to base an evaluation of the possibilities for their use, control, conservation, and protection.

As indicated in the theme chosen for World Day for Water, ground water is seemingly invisible and this presents serious problems in identifying its very existence, much less assessing its quality and quantity. Accurate assessments can only be accomplished through well-planned and well-executed ground water monitoring programs.

Division of Watershed Management for sanitary wastewater discharges and by the Division of Waste Prevention, Industrial Wastewater Program, for industrial discharges. All discharges of industrial contaminants and discharges of over 15,000 gallons per day of sanitary wastewaters into the ground water require a ground water discharge permit. Dischargers include, but are not limited to, facilities discharging a liquid effluent below the land surface or into a percolation pit, pond, or lagoon; facilities discharging liquid effluent into leaching pits, galleries, chambers, trenches, fields, and pipes; facilities discharging a liquid effluent into an injection well; any facility with an unlined pit, pond, lagoon, or surface impoundment in which wastewaters or sludges are collected, stored, treated, or disposed of; or conveyances that collect and convey stormwater runoff contaminated by contact with process water, raw materials, toxic contaminants, hazardous substances, or contact with a leaching facility. Some existing facilities and all new facilities with sanitary wastewater discharges over 10,000 gallons per day also must have a ground water discharge permit.

Discharges to Class I waters (designated as a source of potable water supply) and Class II waters (designated as a source of potable mineral waters for conversion to fresh potable waters) must meet the more stringent of either Massachusett's technology standards or the national primary and secondary drinking water standards. Compounds that are considered toxic or for which there is neither a water quality standard nor a health advisory are prohibited from discharge. These measures serve to ensure that the permitted discharge will be in compliance with ground water standards.

In addition to the stipulation of controls, various state regulations specify standards for chemical constituents in ground water as they apply to the appropriate use (e.g., drinking water standards, irrigation water standards). Ground water standards may be either narrative or numeric. Numeric standards set health-based maximum contaminant levels (MCLs) for specific constituents in ground water. States may independently initiate more restrictive standards. Narrative standards are adopted for contaminants for which numeric standards have not been adopted. Standards may be used to apply limits on allowable discharges from contaminant sources and/or to set contaminant concentration targets or threshold levels for ground water cleanup.

Colorado's Basic Standards for Ground Water provide a framework under which ground waters are classified and protective standards are set. The Basic Standards assign maximum concentrations for a host of organic contaminants applicable to all ground waters. Recent amendments extend the application of an interim narrative standard to all ground waters except those with very high total dissolved solids, i.e., greater than 1,000 milligrams per liter. This action was significant in the overall structure for ground water protection because it establishes a ceiling at which ground water quality must be maintained in cases where some degradation has already occurred. If the water is relatively uncontaminated, water quality must be maintained at "table values" or MCLs. Colorado combines the following standards to form a comprehensive and workable foundation for source control programs:

- Statewide numeric standards to protect public health from organic chemical contamination
- An interim narrative standard to maintain ambient or MCL-level quality of inorganic and metal parameters
- Drinking water/agricultural use classifications and standards for wellhead areas.

Cleanup standards used in **Missouri**'s voluntary cleanup program include a methodology that allows alternative ground water standards to be used on a site-specific basis. These allow the use of risk assessment to develop standards that can be used in place of the direct application of the water quality standards. These procedures set up a tiered approach for reviewing site cleanups and can result in higher standards for contaminant levels remaining in ground water in some cases, provided certain criteria are met. This allows for the efficient use of cleanup resources while maintaining the necessary qualities of ground water.

Ground water monitoring data reported by **Arizona** were compared to state Aquifer Water Quality Standards. Arizona's numeric Aquifer Water Quality Standards are essentially consistent with federal Primary Drinking Water Standards (MCLs as defined under the SDWA). However, narrative standards have been adopted to allow for regulation of pollutant discharges for which no numeric standards exist. The narrative standards state that a discharge cannot cause the following:

- A pollutant to be present in an aquifer at a concentration that endangers human health
- A violation of Arizona's surface water quality standards
- A pollutant to be present in an aquifer that impairs existing or foreseeable uses of that water.

Interagency Coordination

Historically, ground water protection programs have been overseen by many different agencies within the states, territories, and tribes, making coordination difficult for those programs. Coordinating the activities of these agencies to ensure an efficient ground water protection program has become a top priority in many jurisdictions. Many states have developed a plan to coordinate ground water protection programs among their agencies.

The state of **Alabama** recognized that there was a need to coordinate the management of ground water programs and, as a result, set up the Ground Water Programs Advisory Committee (GWPAC) in 1994. The committee includes representatives of state and federal agencies, consultants, water system representatives, and others who work in ground-water-related fields. The meetings are used to dispense ground water program information, receive feedback, and coordinate ground water projects. A subcommittee of agencies involved in areawide ground water monitoring programs was formed in late 1997. This subcommittee is working to maximize resources to provide the best monitoring coverage of the state.

Ground Water Mapping and Classification

States are developing ground water classification systems to aid in the protection and management of aquifers. Classification systems can be used as a basis for the maintenance and restoration of ground water quality, the development of ground water quality standards, and land use and pollution source management and regulation. Most ground water classification systems are based on the understanding that some human activities have the potential to degrade ground water. The systems are designed to restrict such activities to areas overlying aquifers containing lower quality waters while protecting the most vulnerable and ecologically important ground water systems. Most states that have classification systems apply them to the permitting of discharges or potential discharges to ground water and the remediation of contaminated ground water. Some states may also use them for development of new supplies or to site certain types of industries.

A state's classification system is typically designed to first identify and protect water that is currently used or has the potential to be used as a source of drinking water. Some states also place importance on ecologically sensitive aquifers. Aquifers that do not meet requirements or that are unsuitable for use because of poor ambient water quality or because of past contamination are generally classified for other types of uses, such as industrial processes or agricultural use or, in some cases, waste disposal.

Before a ground water classification system can be applied to ground water management strategies, the state's aquifers must be delineated and their quality assessed. Mapping aquifer units is an important step in identifying the potential for interaction between aquifer and surface waterbodies. This information is needed to identify and protect ecologically sensitive aquifers and those important for water supply.

The **Hawaii** Department of Health contracted the Water Resources Research Center (WRRC) at the University of Hawaii to identify and classify aquifers in the state. The WRRC identified general aquifer sectors and smaller aquifer systems for the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii. Each aquifer system was divided into aquifer types that were characterized in accordance with (1) hydrologic factors such as basal, high-level, unconfined, confined, and confined/unconfined conditions; and (2) geologic factors such as flank, dike, perched, sedimentary, or combination aquifer types. They also identified the status of the aquifer types through identification of their development stages, potability/salinity, utility, uniqueness, and vulnerability to contamination. The vulnerability determination applied in this study was based on geographical limits of the resource, interconnection among ground water sources, relatively rapid time of ground water travel, and familiarity with environmental conditions. Vulnerability was ranked high, moderate, or low.

The WRRC studies provided a comprehensive profile of the location, composition, characteristics, and vulnerability of Hawaii's aquifers (Table 7). This information provides insight into how their aquifers formed and the natural conditions that may or may not protect them from anthropogenic impacts. To supplement these data, investigations on surrounding land use activities and their existing and potential impacts to ground water quality are needed. Understanding how aquifers work and what activities contaminate them provides the basis for protection policies and efforts.

Ground Water Monitoring

Various ground water monitoring programs are used by states to collect data on ground water quality. Examples of ground water monitoring that are initiated through state agencies include ambient monitoring and compliance monitoring. Ambient monitoring programs measure background or existing water quality and are used to track long-term trends in contaminant concentrations. Compliance monitoring programs are required by federal or state regulations generally near facilities where ground water contamination has occurred or where there is a potential for release. Compliance monitoring activities measure for specific constituents to ensure that their concentrations in ground water are below regulated levels. States may also rely on monitoring data collected by federal agencies to assess ground water quality.

The **Kansas** ground water quality monitoring network was established in 1976 as a cooperative program between the USGS and the Kansas Department of Health and Environment (KDHE). The KDHE assumed sole responsibility for this program in 1990. Since that time, the program has endeavored to procure data suitable for identifying temporal and spatial trends in ground water quality associated with alterations in land use, the implementation of nonpoint source (NPS) best management practices, changes in ground water availability or withdrawal rates, and shifts in climatological conditions. In addition, the network is intended to assist in the identification of ground water contamination problems.

Currently, the Kansas ground water monitoring network comprises 242 wells used for public or private (domestic) water supply, irrigation, livestock watering, and/or

Table 7. Vulnerability of Hawaiian Aquifers

Island	Number of Aquifer Sectors	Number of Aquifer Systems	Number of Aquifer Types	Number of Unconfined Aquifers	Percent of Aquifer Types Highly Vulnerable to Contamination
Kauai	3	13	120	98	64%
Oahu	6	24	90	66	73%
Molokai	4	16	60	60	98%
Lanai	4	9	22	22	100%
Maui	6	25	113	106	64%
Hawaii	9	24	82	82	84%

industrial purposes (Figure 16). During the period 1996 to 1997, 267 well samples were analyzed for common inorganic chemicals and heavy metals; 267 well samples were analyzed for pesticides; 43 well samples were analyzed for volatile organic compounds (VOCs); and 38 well samples were analyzed for radionuclides. Network wells are sampled for inorganic parameters on each sampling occasion. Wells sampled for pesticides, VOCs, and radionuclides are rotated systematically throughout the network. Five wells in southeastern Kansas are repeatedly sampled for selected radioactive constituents, owing to known contamination in that region of the state.

Comprehensive Data Management Systems

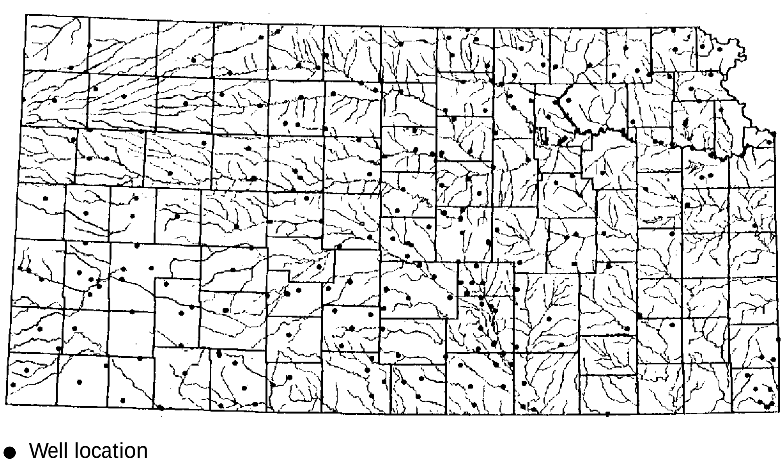
Traditionally, data from monitoring programs have been managed and available only to the specific state agency responsible for their collection. Each agency has typically been responsible for its own data handling and documentation methods, typically paper filing systems or electronic records in the form of small independent databases or spreadsheets. This often prevented the use of historical records in analyses to identify and evaluate long-term trends in ground water quality. Data management has been a limiting factor in monitoring the condition of the state's principal aquifers and the general quality of the nation's ground water resources.

Agencies are beginning to implement more sophisticated data-handling techniques. States are now making progress in developing comprehensive data management systems. These systems will encourage interagency sharing of data and cooperation in planning and implementation of monitoring programs. The interactive database systems that are an integral part of the data network also allow for the use of modern technologies such as geographic information systems (GIS) to display and evaluate data spatially. These advances promise to provide effective management tools for state environmental managers in making planning decisions for implementing long-term pollution prevention policy.

Idaho's Ground Water Quality Plan recognizes an Environmental Data Management System (EDMS) as the state's comprehensive data management system to include data from past, present, and future ground water quality monitoring. Although the EDMS is currently in use, not all relevant ground water quality data are routinely submitted

Figure 16

Kansas Groundwater Monitoring Network



and entered into the system and there is a backlog of past data that could be incorporated into the system. Recent efforts to help increase the amount of data routinely submitted to EDMS include development of a compatible Access database structure that can be placed on individual computers and used for project or program-specific data. Once the data are entered into the Access database, they can be transferred into EDMS.

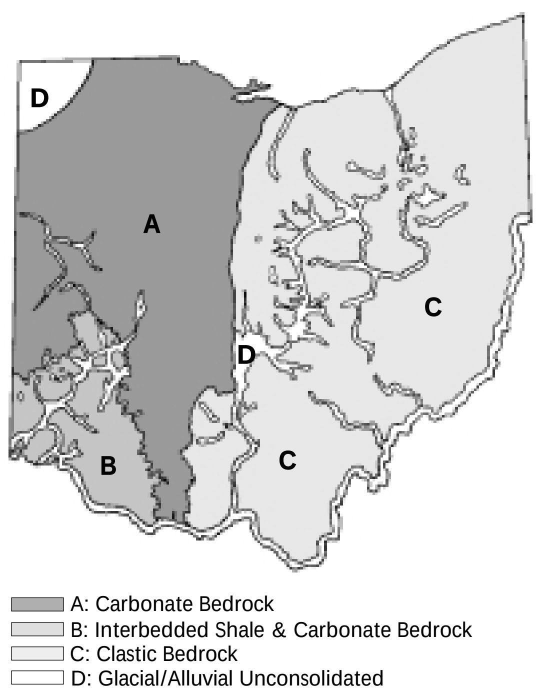
In addition, work is in progress to make EDMS data available on the World Wide Web with direct queries to the EDMS database. For data searches relating to specific geographic areas, map sequences will allow the searcher to visually identify the target area. Parameter selection will then allow "zeroing in" on specific characteristics of available data, providing tabular results from the EDMS database. Searchers with client SQL software (such as MS Access or ArcView 3.0) will be able to query the EDMS database directly through an Internet connection using the appropriate software that links a client to the server.

The **Ohio** Environmental Protection Agency's Division of Drinking and Ground Water has expanded its effort to define ground water quality for the state's major aquifers. This effort reflects the progress made using computerized water quality databases and linking these data to GIS to produce geographic representations of ground water aquifers (Figure 17). The initial focus of this effort has been on data collected through the Division's Ground Water Quality Characterization Program and evaluation of public water supply (PWS) data. Stacking these data against various parameters (aquifer type or depth, confined aquifers, watershed boundaries) and using GIS has enabled Ohio EPA to use these data to define ambient ground water quality conditions. The goal is to use these databases in conjunction with other data to identify areas where ground water quality has been impacted by human activities.

New York State is in the process of developing a comprehensive information base on the geographic distribution, potential productivity, use, and quality of its ground water resources along with GIS coverage of the distribution of potential sources of ground water contamination. Information systems

Figure 17

Ohio's Major Aquifer Settings



include ground water resource mapping, well-log data, water quality data, and information on the distribution of regulated facilities and other potential contamination sources. Such a comprehensive and integrated system will serve many program applications, including the state's Source Water Assessment Program, local government wellhead protection programs, and support for priority decisions for many state prevention and remediation programs.

Prevention Programs

States develop prevention programs to prevent and reduce contamination of ground water. They serve to

- Analyze existing and potential threats to the quality of public drinking water
- Focus resources and programs on drinking water source protection
- Prevent pollution at the source whenever feasible
- Manage potential sources of contamination
- Tailor preventive measures to local ground water vulnerability.

Examples of programs that fully or in part address pollution prevention include: Source Water Assessment Program (SWAP), Pollution Prevention Program, Wellhead Protection Program (WHPP), aquifer vulnerability assessments, vulnerability assessments of drinking water/wellhead protection, Pesticide State Management Plan, Underground Injection Control (UIC) Program, and Superfund Amendments and Reauthorization Act (SARA) Title III Program. Prevention programs are critical to the effective long-term management of ground water resources.

The **Montana** Wellhead Protection Plan contains many elements of source water protection and, as a consequence, has been renamed the Montana Source Water Protection Program. Montana will develop a GIS-based approach to implementing this program that will result in a technical report being provided to each of Montana's 1,900 public water supply systems (PWSs). The technical plan will overlay the source water protection area delineation on a base map. The origins of regulated contaminants that pose an acute health risk or those that have been detected through PWS monitoring will be the focus of the potential contaminant source inventory. These sources and land uses will also be shown on the base map. Other potential contaminant sources with regional and local significance may also be identified. Susceptibility will be assessed based on intake characteristics, depth to ground water, soil characteristics, slope, aspect, separation distances, contaminant characteristics, and onsite use of Best Management Practices. The delineation and assessments will be made available to the public using the Internet, PWS consumer confidence reports, and local governments and libraries.

The Pollution Prevention Bureau of Montana's Department of Environmental Quality will be responsible for implementing the source water protection program. As part of this effort, they will

- Conduct delineation and assessments internally
- Negotiate and administer contracts to complete assessments by external entities where appropriate
- Coordinate statewide source water protection efforts
- Make information available on potential contaminant sources
- Provide technical assistance to local communities on source water protection plan development.

In late 1998, approximately 75 community PWSs out of a possible 610 were in the early stages of the source water protection planning process, and another 10 PWSs had certified source water protection plans in place in Montana. Hence, the state of Montana is right on target to meet the federal government's requirements that delineation and assessments be completed for all PWSs by May 2003.

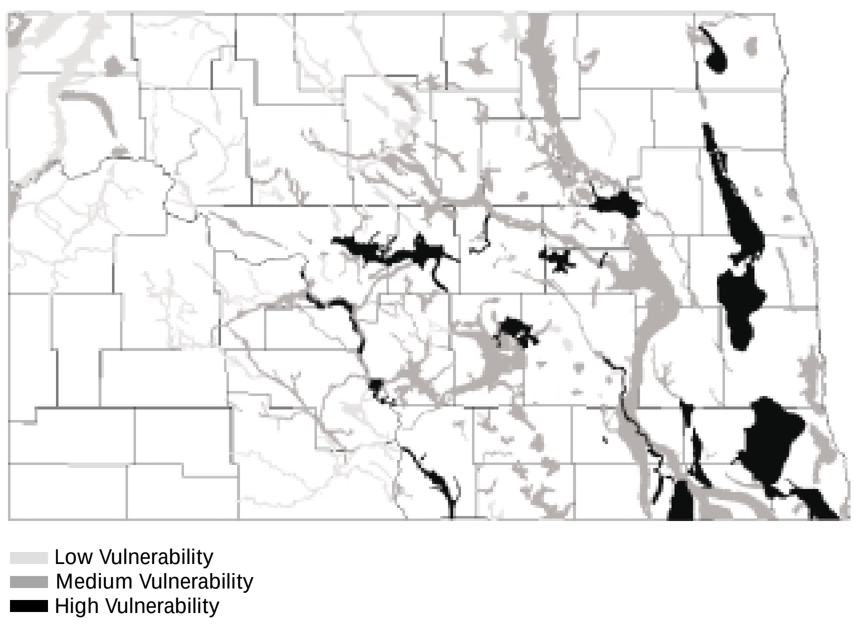
To make best use of limited financial and human resources, the state of **North Dakota** prioritized aquifers in order of their susceptibility to contamination. Prioritization was completed using a modified Ground Water Vulnerability Model to calculate the relative aquifer vulnerability score based on depth to water, recharge, aquifer media, topography, impact of the vadose zone, conductivity, ground water appropriation, and land use. Each aquifer was evaluated as a discrete whole unit; if all portions of the aquifer had similar characteristics, it was subdivided into subaquifer units of similar hydrologic characteristics. The evaluation does not identify critical recharge areas or areas where special management practices must be applied. Rather, the evaluation identifies aquifer settings where an increased contamination potential exists. Aquifers identified as having an elevated potential for ground water contamination are highlighted as requiring increased assessment and educational activities relating to ground water quality protection (Figure 18).

Federal Programs

The protection of our nation's ground water resources is addressed

Figure 18

Relative Aquifer Vulnerability in North Dakota



CWA Section 102

The administrator shall . . . prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground water and improving the sanitary condition of surface and underground waters.

under both the Clean Water Act and the Safe Drinking Water Act. The CWA encourages ground water protection, recognizing that ground water provides a significant proportion of the base flow to streams and lakes. In the CWA (Public Law 92-500) of 1972 and in the CWA Amendments of 1977 (Public Law 95-217), Congress provided for the regulation of discharges into all navigable waters of the United States. Ground water protection is addressed in Section 102, providing for the development of federal, state, and local comprehensive programs for reduction, elimination, and prevention of ground water contamination. Two very important aspects under the CWA are the development of Comprehensive State Ground Water Protection Programs (CSGWPPs) and the measurement of national progress in achieving state water quality standards.

The SDWA was passed by Congress in 1974 and amended in 1986 and 1996. Under the SDWA, EPA is authorized to ensure that water is safe for human consumption. One of the most fundamental ways to ensure consistently safe drinking water is to protect the source of that water. Source water protection of ground water is achieved through four programs: the Wellhead Protection Program, the Sole Source Aquifer Program, the Underground Injection Control Program, and, under the 1996 Amendments, the Source Water Assessment Program.

Clean Water Act

One of the goals of the CWA is to achieve an interim water quality level that protects the desirable uses that water quality should support. These “beneficial” uses include drinking water as well as primary contact recreation, fish consumption, and aquatic life support.

Under the authority of the CWA Section 102, states are developing CSGWPPs tailored to their goals and priorities for the protection of ground water resources. One of the primary purposes of a CSGWPP is to provide a framework for EPA to give greater flexibility to a state for management and protection of its ground water resources. CSGWPPs guide the future implementation of all state and federal ground water programs and provide a framework for states to coordinate and set priorities for all ground-water-related activities.

Comprehensive State Ground Water Protection Programs

CSGWPPs provide the means for federal and state programs that have ground water protection responsibilities to coordinate efforts and to focus on protection of priority ground waters, especially those used for drinking water supplies. They are the focal point for a new partnership between EPA, states, tribes, and local governments to achieve a more efficient, coherent, and comprehensive approach to protecting the nation’s ground water. The goal of CSGWPPs is to prevent contamination and to consider use, value, and vulnerability in setting priorities for both prevention and remediation and to strengthen state watershed approaches by providing an essential linkage between the state’s ground water and surface water protection programs.

EPA is committed to working with states in developing and carrying out the CSGWPP approach. Following EPA endorsement of a Core CSGWPP, the states work in partnership with EPA to further incorporate additional state and EPA programs into the CSGWPP, thereby leading to a Fully Integrated CSGWPP. Attainment of a Fully Integrated CSGWPP means that ground water protection efforts are coordinated and inclusive of all federal, state, tribal, and local programs. The implementation of a CSGWPP provides a forum for multiple agencies and multiple disciplinary approaches to be brought together on a regular basis for the purpose of monitoring and protecting ground water resources.

Figure 19 shows the state's progress in implementing the CSGWPP approach. As of 1999, EPA had approved 11 Core CSGWPPs. An additional four states are expected to have approved Core CSGWPPs in fiscal year 2000. In addition, many other states have developed programs that utilize this concept of comprehensive planning to align their priorities across state and federal programs.

Safe Drinking Water Act

The 1986 and 1996 Amendments to the SDWA provide for an expanded federal role in protecting drinking water and mandating changes in nationwide safeguards.

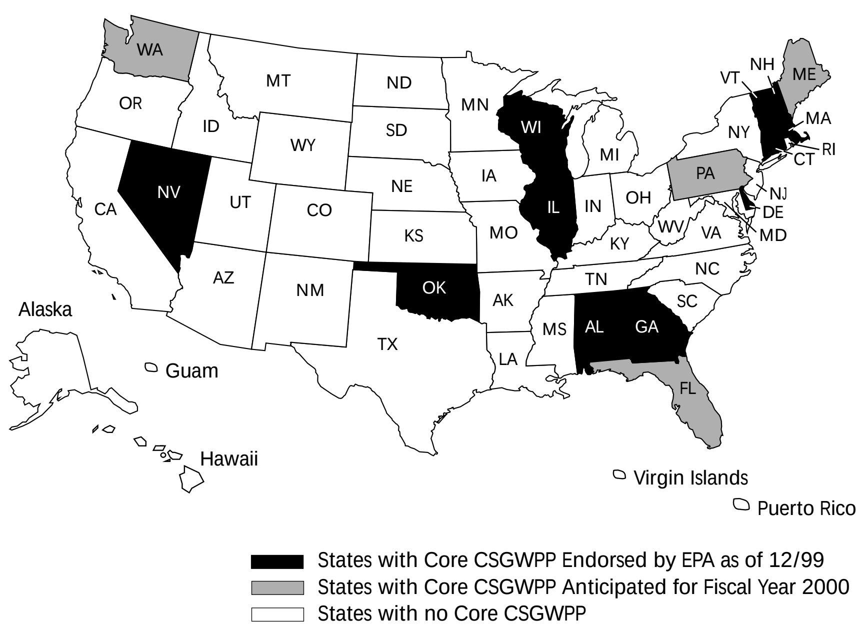
Source Water Assessment and Prevention Programs

Section 1453 of the SDWA as amended in 1996 requires all states to complete assessments of their public drinking water supplies. By 2003, each state and participating tribe will delineate the boundaries of areas in the state (or on tribal lands) that supply water for each public drinking water system, identify significant potential sources of contamination, and determine how susceptible each system is to sources of contamination (Figure 20). The SDWA directs the states to use all available data, including federal information.

By February 1999, states were required to submit plans for implementing Source Water Assessment

Figure 19

States with Core CSGWPP



Source: U.S. EPA, Office of Ground Water and Drinking Water, 1999.

Figure 20

What Actions Are Needed to Complete a Local Source Water Assessment?

Delineation

Delineation of a source water protection area (e.g., wellhead or surface water or ground water/surface water) (e.g., fixed radius, time of travel, topographic watershed or watershed area)

Establish Delineation Policy with Best Available Data

Inventory

Identify significant potential sources of contamination, to the extent practical

- Identify contaminants
- Inventory sources of those contaminants
- Map significant potential sources

Establish Inventory with Best Available Data

Susceptibility Analyses

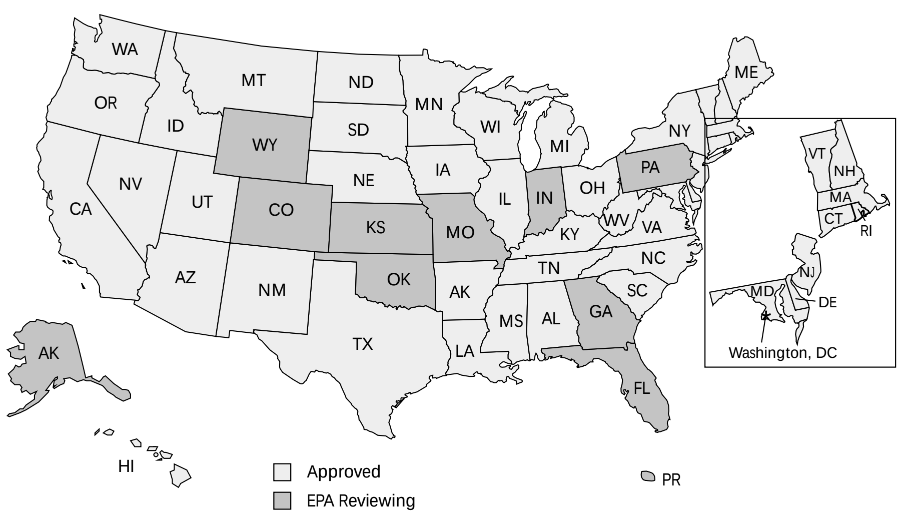
Hydrologic and hydrogeologic analysis of the source water protection area (e.g., depth to water, water flow rates)

(No monitoring or modeling required)

Do Analyses with Best Available Data

Figure 21

Status of Source Water Assessment Programs (SWAPS)



Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

Programs (SWAPs). Many of the state source water protection programs use data from other, related watershed-type survey activities, such as 305(b) monitoring and assessment activities. Furthermore, program plans use components of existing state Wellhead Protection (WHP) Programs, including source water delineation, contaminant source inventories, management measures, and contingency planning.

Program reviews and approvals are conducted by regional offices. Under an agreement worked out by EPA's Office of Ground Water and Drinking Water and the Regions, EPA Headquarters (HQ) concurred on the first program from each Region, which included the programs submitted by the following states: New Hampshire, New York, West Virginia, Louisiana, Nebraska, Ohio, South Dakota, Oregon, and California. Kentucky was the first state source water assessment program approved. EPA has since approved the remaining states. Figure 21 shows the current status of approved programs. Assessments for all public water systems must be completed within 2 years of EPA approval. As allowed under the provisions of the SDWA, some states requested and were granted an 18-month extension from the date of approval to complete their assessments.

With very few exceptions, most states met the February 1999 submission deadline. All assessments are expected to be completed by June 2003. As of January 1, 2000, EPA had approved 39 programs.

Enhanced Public Involvement in the Development of State Source Water Assessment Programs

A significant aspect of state Source Water Assessment Programs is public involvement in their development. This involvement creates a mechanism for the states to consider the ideas and concerns raised by various interested organizations and individuals about SWAP issues, thus leading to improved state SWAP programs. Another equally important result of the public participation efforts is the identification of informed stakeholders at the state level who are committed to ensuring the success of the program. Obtaining this involvement and support of the state SWAP programs early in the process is a key component in ensuring that the assessment will be successful and that it will lead to drinking water protection efforts.

The EPA's Office of Ground Water and Drinking Water considered early public involvement in state SWAP development as a high priority and provided several grants to organizations and states to ensure that this participation occurred during 1998 and early 1999. For instance, a grant was provided to the New York Rural Water Association to conduct training workshops for water suppliers, public officials, and educators to facilitate their involvement in state SWAP efforts. A similar grant was awarded to the Georgia Department of Environmental Protection for outreach to local public officials on SWAP issues. Hawaii's Department of Health is involving students in the assessment process for their school's water supply, and the Oregon Department of Environmental Quality received a grant for the creation of a SWAP community pamphlet and regional workshops to introduce various stakeholders to the SWAP process.

Grants were also given to various regionally based public interest organizations to conduct workshops that explain the SWAP process to environmental, public health, and other activist organizations and encourage their involvement in the development of these states' SWAPs. For instance, Clean Water Fund local offices in New Jersey, Texas, Colorado, and California used EPA funds to conduct workshops that resulted in numerous public comments on draft state programs and created public support for drinking water protection priorities.

EPA believes that this effort to include the public in the development of SWAPs will benefit states as they implement their assessments and create public support for local drinking water source protection programs in the future.

In most instances, the state will perform the assessments or at least complete delineations of source water protection areas (SWPAs). States are relying on individual public water supply systems located within the SWPAs to conduct contaminant source inventories and perform susceptibility analyses based on inventory information. Some states will complete the first and last steps of the assessment (delineations and susceptibility analyses) using data and information gathered by the PWSs on contaminant sources. The state will generally review the final product for consistency with the SWAP program goal "for the protection and benefit of public water systems."

Data and information sources outlined in the majority of individual state SWAPs reviewed thus far include

- EPA-approved WHP Programs
- CERCLA and RCRA databases
- Underground Injection Control well monitoring, closure, and inventory information
- Underground Storage Tank inspection, monitoring, removal and cleanup records
- State Sanitary Survey Inspection data (septic tanks, etc.)
- State Pesticide Monitoring plan records
- Nonpoint source permitting application and inspection data
- PWSs monitoring waiver applications and inspection data
- Land use and GIS data
- Historical and archival information on significant contamination incidents involving both ground- and surface-water-based drinking water supplies.

Drinking Water Source Agreement: Human Health and Ecosystem Protection in One Watershed Framework

In February 1998, President Clinton initiated the Clean Water Action Plan to increase coordination among the existing authorities, programs, and resources for water quality management at the federal and state level. A key element of the *Action Plan* is the integration of public health and aquatic ecosystem goals when identifying priorities for watershed restoration and protection.

The Clean Water Action Plan initiative gives states the chance to reexamine their current prioritization schemes, including how drinking water source protection and ground water management are factors in determining where to direct programs for water quality protection and restoration. Success will require a shift in thinking and active involvement by drinking water and ground water programs in the framing of water quality management agendas.

To demonstrate federal support of the improved integration of drinking water source protection into a watershed framework, nine federal agencies signed an agreement on November 13, 1998:

- Tennessee Valley Authority
- U.S. Postal Service
- Environmental Protection Agency
- Department of Agriculture
- Department of Interior
- Department of Defense
- Department of Energy
- Department of Transportation
- Department of Commerce.

The intent of the agreement is to encourage federal/state partnering on drinking water quality initiatives, increase federal awareness of the linkages between water quality initiatives and drinking water concerns, and to encourage federal agencies to use the results of the assessment when developing relevant resource, technical assistance, facility management, and water resource plans.

By 2000, the source water agreement calls for regional multiagency summaries of federal initiatives relevant to drinking water source protection, examples of new drinking water source protection partnerships, and improved access to relevant data resources.

Most state SWAPs rely heavily on EPA-approved WHP Programs as the basis for ground-water-based drinking water supply protection and have essentially met the source water protection requirements of SDWA for completing assessments for ground water sources under the WHP Programs. In the few cases where essential elements of a WHP Program need to be modified or revised under the SWAP plan, the necessary changes are reviewed and approved by EPA. For example, for surface-water-based drinking water supply protection, most state SWAPs have adopted a watershed protection approach, including special scrutiny of areas where ground water/surface water interactions are likely to occur. These areas may require additional management or protection measures to ensure complete source water protection; in these cases, the original WHP Program approach (e.g., delineation, contaminant source management) may be modified as appropriate to enhance this comprehensive approach.

Several states have exemplary provisions within the required elements of their SWAPs. A good example is South Dakota's source water assessment dispute resolution process. This process gives owners/operators or concerned citizens a negotiable risk-ranking strategy for disputing the results of the susceptibility analysis for a particular PWS (e.g., ranking criteria too rigorous or insufficiently protective). Under the plan, PWS owners/operators or concerned citizens may review the method and the risk factors applied to the contaminant sources or activities listed as potential sources of concern during the inventory and susceptibility determination phases of the assessment.

Local community leaders and planners will be encouraged to examine the evidence provided by the complainant (e.g., risk factors inappropriately assigned or not considered) and to recalculate the risk scores and evaluate the change in the overall risk rating. If the state recalculates the risk scores, the results are provided as an amendment to the original assessment report, to the individuals who requested the revision, and to the PWS. In either case, the state has the responsibility for making the final decision on the susceptibility rating for a potential contaminant source.

The results of the assessment reflect the state's analysis of the susceptibility of the PWS to the inventoried sources of contamination in that area. EPA expects the assessments to take the form of a summary-type document or report, with the size or volume of material contained in the report dependent upon the size of the SWPA inventoried and the complexity of the hydrogeologic setting of the SWPA. The assessment results need not be highly detailed, but they must convey to the public the results of the source inventories and susceptibility determinations. The results can be in narrative form (e.g., susceptibility for your PWS is high-medium-low) or in a tabular ranking or rating system (e.g., on a scale of 1 to 10, your system ranks 6).

The assessments need to be readily understandable to the public and contain enough information set forth clearly and concisely to enable any person to interpret how potential sources or activities within their

Section 1429 Ground Water Report to Congress

Congress enacted the Safe Drinking Water Act (SDWA) to protect the quality of drinking water in the United States. Because approximately half of the nation's population uses ground water as a drinking water source, the Act has become one of the principal authorities for managing and protecting ground water resources. Under Section 1429 of the 1996 amendments to the SDWA, Congress authorized EPA to report on the current status and effectiveness of state ground water protection efforts and to examine our nation's approach to protecting ground water. The first Ground Water Report to Congress under Section 1429 was released in late 1999. Additional reports are required every 3 years thereafter.

To complete the Report, EPA compiled data from the following sources of information:

- Existing literature and research reports developed by federal agencies, states, universities, and private research organizations
- A survey of state ground water management programs completed in April 1999
- Data reported by states in the Section 305(b) State Water Quality Reports.

EPA also convened a state and federal agency Work Group to review the report and to assist in compiling and reviewing information from the states. Based on these sources of information, EPA concludes that states have made progress in remediation or prevention of specific types of ground water contamination problems. However, a more comprehensive, resource-based approach would yield better results for effective ground water protection. More than a dozen states have begun to take a comprehensive look at ground water protection, but only a few states have prioritized protection activities or identified funding to meet this protection approach. Although the importance of a more comprehensive effort is recognized, more resources are needed to accomplish the priority setting, coordinating of activities, and monitoring and assessment deemed necessary to better protect ground water.

SWPA impact the quality of their drinking water. Maps will be provided to show the delineated SWPA, the sources of contamination inventoried within that area, and, if desired, the final results of the susceptibility determination for each PWS on the map. Persons wishing to examine the raw data from which the delineation, source inventories, and susceptibility determinations were derived may do so by request to the state. Final results of assessments can be sent out with water bills, posted on the internet, maintained in public libraries, and referenced in toll-free hotline access. In addition, the results of the assessments are required to be communicated in the Consumer Confidence Reports issued by every PWS, which describe the condition, quality, and safety of public drinking water delivered to the consumer.

Wellhead Protection

The 1986 Amendments to the Safe Drinking Water Act established the Wellhead Protection Program. It is essentially designed to provide a pollution prevention program for underground sources of drinking water. Under Section 1428 of the SDWA, each state must develop a WHP Program to protect wellhead areas from contaminants that may have an adverse effect on human health. Protection is achieved through (1) the identification of areas around public water supply wells that contribute ground water to the well, and (2) the management of potential sources of contamination in these areas to reduce threats to the resource.

Before the SDWA Amendments of 1996 established the Source Water Assessment and Protection Programs, the WHP Program was the nation's only federally mandated drinking water source protection program and, as such, dealt solely with ground water sources (including ground water under the influence of surface water). With the passage of the 1996 Amendments to SDWA, the WHP Program assumed new prominence and a higher profile in drinking water source protection, becoming the cornerstone in states' development of Source Water Assessment and Protection Programs. With these new programs now dealing with surface water as well as ground water sources of drinking water, states with EPA-approved WHP Programs in place have essentially met the ground-water-based requirements for Source Water Assessment Programs under SDWA 1996. As EPA reviewed individual state Source Water Assessment Programs for approval starting in February 1999, EPA and the states looked at individual elements of approved WHP Programs to see if any modifications or refinements were necessary in the technical or program implementation elements (e.g., wellhead protection area delineations; contaminant source management strategies) to enhance the state's approach to implementation of SWAPs.

Although states are given the freedom to develop WHP programs that best meet their needs and particular regulatory and hydrogeologic environment, the SDWA stipulates that WHP operations plans must have EPA approval. For EPA approval to be granted, state WHP programs must contain specific elements addressing the roles and responsibilities of state and local governments, delineation of wellhead protection areas, potential contaminant source inventory procedures, contaminant source management and control procedures, contingency plans for alternative water supplies, new well/well siting standards, and public participation.

As of March 1, 1999, almost 90% of the states and territories had developed and implemented WHP programs. Specifically, 48 states and 2 territories have EPA-approved WHP Programs in place and 2 states are continuing their efforts to develop an approved WHP Program (Figure 22). Most of these state WHP Programs are based on existing ground water and drinking water protection programs.

Each state with an EPA-approved WHP program is also required to submit a biennial status report describing the state's progress in implementing the program. States with approved programs have complied with the required submittals

Figure 22

WHP Approval Status as of December 1999

Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

for three biennial reporting periods, ending FY93, FY95, and FY97. The deadline for the 2-year period ending in FY99 was October 30, 1999. The 1997 biennial report, released in December 1999, indicates that 42 of 44 states and 2 territories with approved programs have submitted reports for FY97. State reporting indicates that a total of 6,570 community water supply systems have Step 5 in place. Figure 23 illustrates all five steps of implementation for each reporting period.

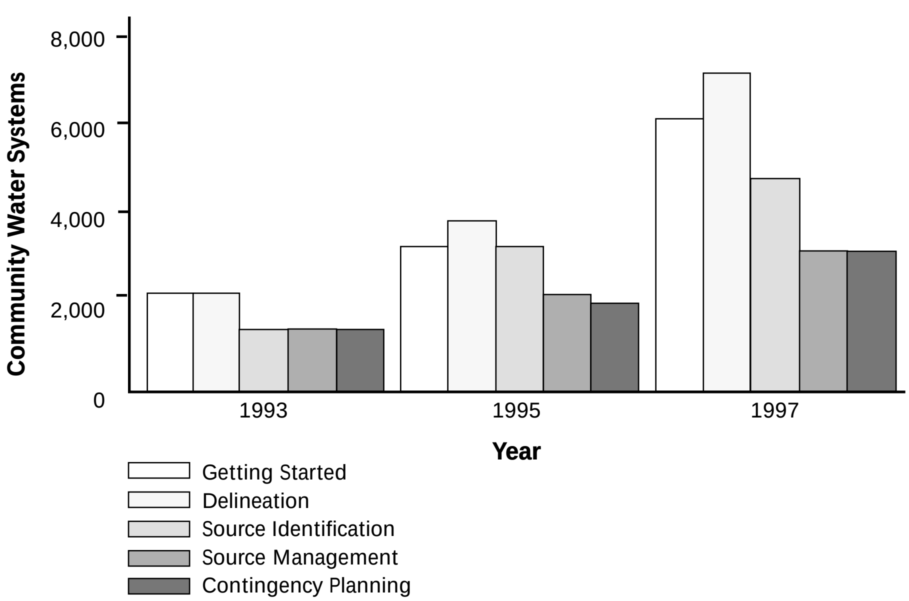
EPA's Office of Ground Water and Drinking Water also supports the development and implementation of WHP programs at the local level through many efforts. For example, EPA-funded support is provided through the Ground Water/Wellhead Protection programs of the National Rural Water Association (NRWA). Currently, these state Rural Water Association programs are being implemented voluntarily in 48 states. In each of these states a ground water technician works with small and rural communities to help them develop and implement WHP plans. These plans are integrated with the WHP program so that they meet state requirements. Only Alaska and Hawaii are not included in the program at this time.

This effort with NRWA began in March 1991. As of December 31, 1998, over 4,500 communities had become involved in developing local WHP plans. These 4,500 communities represent over 9,900,000 people. Over 2,800 of these communities have completed their plans and are managing their wellhead protection areas to ensure the community that their water supplies are protected. EPA has also funded Wellhead Protection workshops for local decision makers. Over 243 of these workshops have been held in 48 states. The workshops have been attended by 8,500 people.

Another effort supported by EPA's OGWDW is the Groundwater Guardian Program, an international program of The Groundwater Foundation. Groundwater Guardian empowers citizens to initiate ground water protection projects in their communities. Communities earn Groundwater Guardian designation for their work to protect local ground water supplies. Their activities range from education and awareness programs to full implementation of WHP plans and local

Figure 23

Wellhead Protection Implementation Nationwide



Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

land use ordinances. Regional and state agencies, in addition to organizations and businesses, earn designation as affiliates by supporting the efforts of nearby Groundwater Guardian communities with educational materials, technical support, and/or financial assistance. National entities earn designation as national partners by supporting the long-term sustainability of the program. Interested citizens can learn more about participating in Groundwater Guardian by contacting The Groundwater Foundation toll-free at 800-858-4844 or by visiting their website at *www.groundwater.org* to request a copy of *Guide to Groundwater Guardian*.

Sole Source Aquifer Protection Program

Congress first established the Sole Source Aquifer Protection Program in 1974 under Section 1424(e) of the Safe Drinking Water Act and reauthorized the program under the August 1996 SDWA Amendments. The program allows communities, individuals, and organizations to petition EPA for protection of the aquifer that is the "sole or principal" source of drinking water for the local population. Since the first sole source aquifer designation of the Edwards Aquifer near San Antonio, Texas, in 1975, there are now 69 designations in 24 states and Guam.

A region is eligible for sole source aquifer status if more than 50% of the population in the defined area relies on the designated aquifer as their primary source of drinking water. Once EPA designates an aquifer through a public process, EPA has the authority to review and approve federal financially assisted projects that may potentially contaminate the sole source aquifer. If the proposed project poses no threat, then the project continues as planned. However, if there is potential for contamination of the aquifer, then EPA works with the project leader and associated federal agency to recommend engineering, construction, or design modifications. Some examples of federally funded projects that EPA reviews include

- Transportation-related improvement and construction

- Infrastructure upgrades of public water supply systems and wastewater facilities

- Agricultural projects involving dairies and feedlots that involve animal waste management concerns

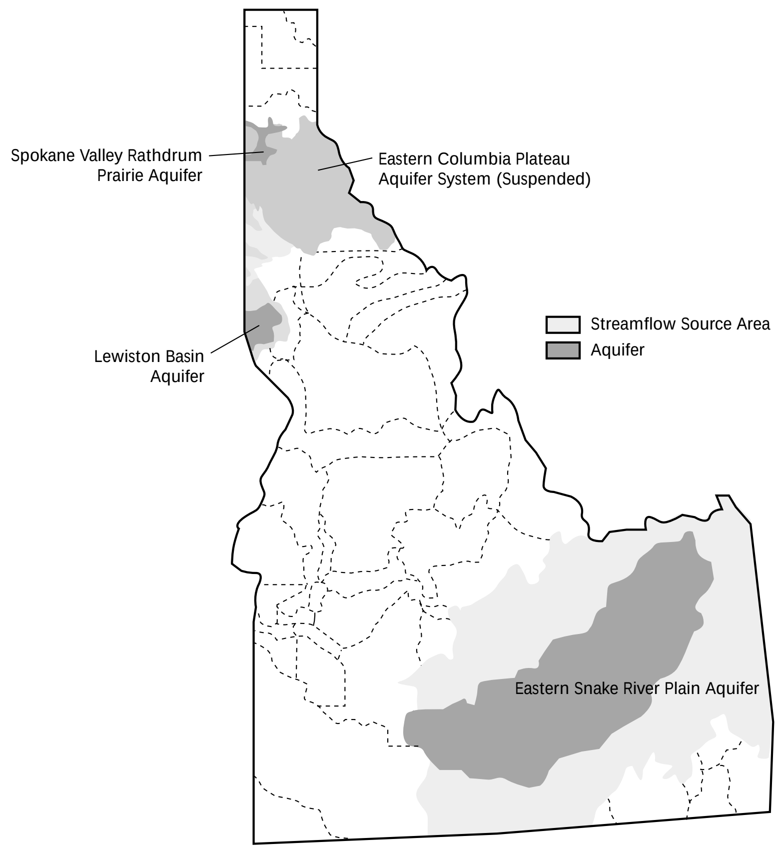
- Construction of multifamily housing, business centers, gasoline stations, and hospitals.

These types of projects often include activities that may impact ground water quality. This does not mean that these projects cannot go forward in a sole source aquifer area, but rather that the project needs to take special measures to minimize the risk of contaminating the aquifer. Frequently, modifications are made for storm water runoff, hazardous waste management, underground storage tank placement and containment, proper

HIGHLIGHT HIGHLIGHT HIGHLIGHT

Eastern Snake River Plain Sole Source Aquifer

On March 11, 1977, a local ranch owner near Hagerman, Idaho, petitioned EPA to designate the Eastern Snake River Plain Aquifer (ESRP) in south central Idaho as a Sole Source Aquifer (SSA). Despite complicated technical and political issues, the ESRP was finally designated by the Regional Administrator of EPA Region 10 on October 7, 1991. The aquifer and streamflow source area are presented in the figure.



Eastern Snake River Plain Aquifer and Streamflow Source Area

The ESRP Aquifer contains most of the population of southern Idaho and extends from the Wyoming border across south central Idaho. The aquifer is a structural basin filled with a thick sequence of Tertiary- and Quaternary-aged highly fractured volcanic basalt from lava flows. Overlain by younger glacio-fluvial deposits and flood plain colluvium, the aquifer is a highly productive ground water resource that provides roughly 80% of the industrial, commercial, and domestic drinking water to over 400,000 residents. Approximately 70% of the citizens in the area rely on the aquifer to supply their primary source of drinking water. Protecting ground water from nutrient loading from poorly managed animal feeding operations, leaking sanitary sewer pipes, failing onsite septic systems, unsealed private drinking water wells, and stormwater runoff has become increasingly difficult because of rapid growth of both industry and agriculture over the aquifer area.

Under EPA's Sole Source Aquifer Protection Program, risk evaluations are performed to determine the potential impacts that a federally funded development project may have on ground water quality. The intent of this program is to ensure that the federal government is not funding projects that may adversely impact ground water quality in the ESRP. Potential projects may include new or expanded dairy facilities, apartment buildings, business development projects, and transportation improvements and water system upgrades.

In 1998, EPA Region 10 reviewed 44 projects, 35 of which were proposed for the ESRP. One such project EPA reviewed was a proposed gas station and convenience store to be located in south central Idaho. In partnership with the U.S. Department of Agriculture–Rural Development, EPA was asked to review this project that was guaranteed for over $1 million of federal financial assistance. Upon review, EPA recommended that the gasoline storage tanks needed proper certification and installation. Where dry wells were proposed for stormwater disposal, EPA recommended grassed retention basins for treating stormwater runoff before it infiltrated the subsurface. EPA worked with the project proponent, architects, and engineers to design the basins and incorporate an underground oil/water separator tank into the project design to treat any large petroleum spills before the effluent is discharged to the grassed retention basins. EPA also recommended the development of a spill response and containment plan for emergency response procedures and provided up-to-date information on the Underground Storage Tank Regulations and registration procedures. The result was a gas station designed to substantially minimize the impact to ground water quality and prepared to respond to handle emergency situations.

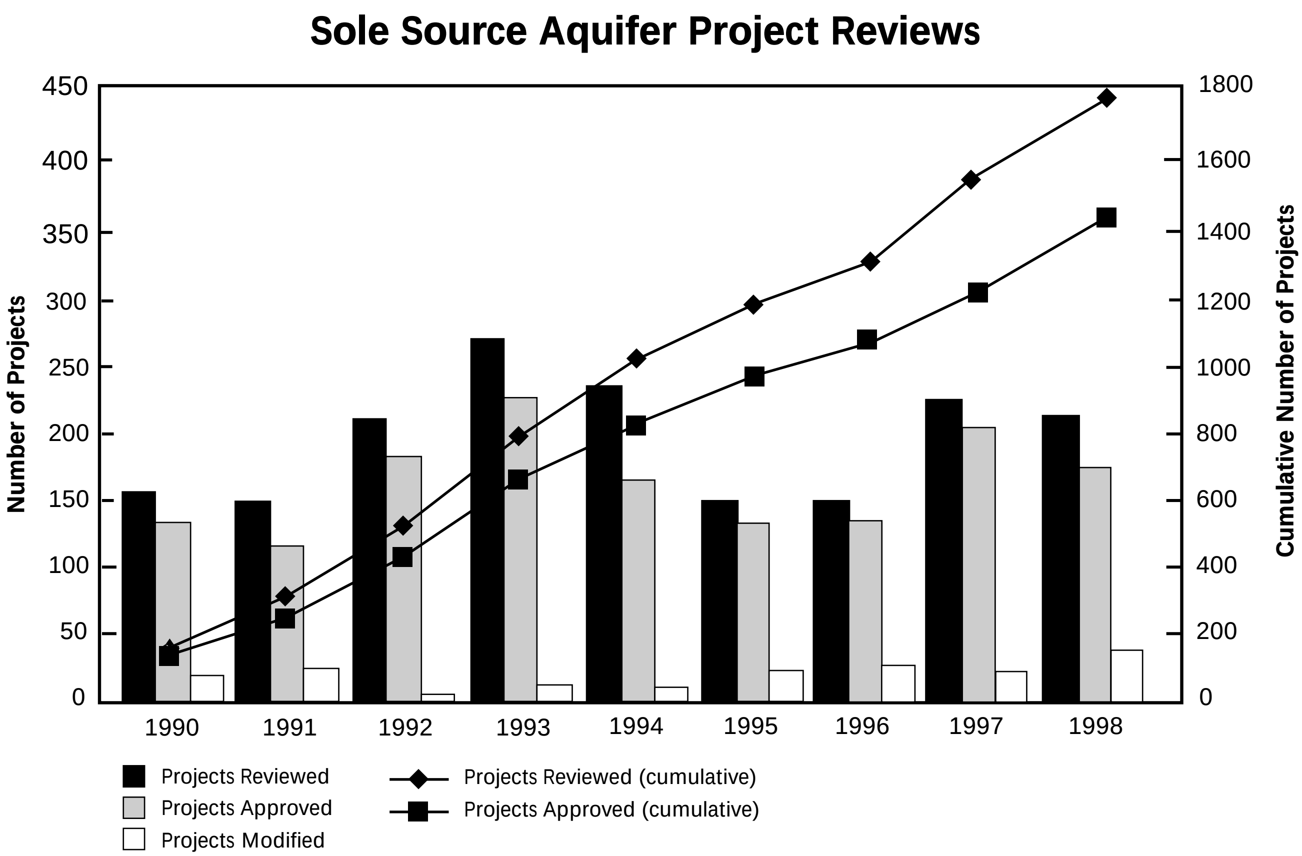
location of large-capacity onsite sewage systems, protective containment of large equipment or truck refueling stations, and provisions for proper disposal and containment of aircraft deicer compounds.

Nationwide, from January 1997 to December 1998, EPA reviewed a total of 439 projects with the project leaders to protect drinking water resources (Figure 24 and Table 8). Reviews occurred in 31 of the 70 aquifers located in 18 states. EPA completed over 95% of the project reviews in cooperation with the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Agriculture's Rural Development Program (USDA-RD), and the U.S. Department of Transportation's Federal Highway Administration (FHWA).

Underground Injection Control Program

EPA protects ground water from a potential source of contamination—underground injection. EPA's Underground Injection Control (UIC) Program focuses on ground water that is used or may be used by a public water system. EPA sets minimum requirements for state programs to protect ground water from injection of waste and other

Figure 24



Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

fluids that contain harmful contaminants. Injection means the subsurface emplacement of fluids through wells, shallow disposal systems, and similar practices.

EPA describes different kinds of injection methods as “wells” and regulates five categories or “classes” of injection wells to ensure that they do not endanger underground sources of drinking water (USDW). Table 9 details the five classes of wells.

EPA and states ban Class IV wells unless they are authorized for ground water cleanups. Most Class V wells inject untreated wastewater above the water table and pose the greatest risk to drinking water sources. Typical Class V wells include stormwater and agricultural drainage wells, large septic systems and cesspools, dry wells, floor drains, and similar types of shallow disposal systems that discharge to ground water.

EPA is studying the prevalence and potential risk of Class V wells in the United States; current estimates range from 700,000 to 1 million wells. The UIC Program does not regulate small septic systems and cesspools that are used by fewer than 20 people and are used only for sanitary waste disposal.

Research Related to Protection of Drinking Water

■ In 1998, EPA completed a feasibility study looking at existing federal reporting requirements. The feasibility study showed that all EPA offices and states are moving toward electronic reporting, which should reduce the state reporting

Table 8. Summary—Fiscal Year Postdesignation Project Reviews (1990-1998)

Fiscal Year	Number of Projects Reviewed[a]	Funds Affected ($)	Number of Projects Approved	Number of Projects Modified	Number of Projects Disapproved or Not Recommended
1990	159	571,748,000	136	20	0
1991	152	570,886,000	117	25	4
1992	214	1,818,665,000	186	6	1
1993	275	2,078,266,000	231	13	0
1994	239	1,173,545,000	168	10	0
1995	153	307,153,000	130	20	3
1996	150	1,756,535,000	127	23	3
1997	225	>8,002,375,994	204	21	0
1998	214	>3,378,040,822	175	39	0
Total	1,781	>19,657,214,816	1,474	177	11

[a]Differences in annual totals by category are due to projects “under review” at year’s end.
Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

Table 9. Injection Wells in 1998

Well Class	Number of Wells (rounded to nearest 100)	Description of Injection Practice
Class I	500	• Inject fluids into deep, confined geologic formations • Associated with municipal or industrial waste disposal, hazardous or radioactive waste sites
Class II	164,300	• Inject fluids used in oil and gas production into deep, confined geologic formations
Class III	29,600	• Inject fluids into shallower formations for mineral extraction
Class IV	Banned by all states and EPA under the Safe Drinking Water Act unless authorized for ground water cleanup.	• Inject hazardous or radioactive wastes directly or indirectly into drinking water sources
Class V	Actual numbers unavailable	• Includes all injection methods not included in other four categories.

Source: U.S. EPA Office of Ground Water and Drinking Water, 1999.

burden and make available much needed resources to address high-risk Class V injection wells in critical source water protection areas.

■ EPA is studying the potential risks to underground sources of drinking water posed by hazardous waste (Class I) injection wells. One study examines the treatment of wastes to render them noncorrosive, nontoxic, nonreactive, and nonignitable. This study, when completed, will be sent to Congress in 2000. A second study examines the safety of injecting hazardous waste into deep formations and the interaction of wastes with formation fluids.

■ Class V wells and the risks these wells pose to drinking water are another area of investigation. One study, completed in September 1999, was related to a consent decree that required the Agency to complete a study on all Class V well types not addressed by the November 1999 final rule. Another study identifies shallow disposal systems that contribute to drinking water contamination at Superfund sites throughout the United States.

■ EPA also began a study of the resource needs of state programs to implement UIC requirements for Class V wells. The study will continue through 2000.

UIC Technical Workgroup Study Technical Issues

The UIC Technical Workgroup, made up of representatives from EPA regional and national offices, examines technical issues facing the direct implementation of UIC programs to ensure existing UIC requirements are adequate to protect USDW. Some of the recent issues studied include

■ Fracture slurry injection

■ Downhole hydrocarbon separation

■ Existing Class II permit "boilerplate" language

■ A compilation of Naturally-Occurring-Radioactive Materials (NORM) studies.

The Workgroup has developed recommendations for consideration by the national program managers.

Legal Challenges Facing State Programs

■ **Texas Audit Privilege**. In 1995, Texas passed legislation granting privilege and immunity to companies that voluntarily disclosed information on violations of applicable environmental laws. EPA was concerned that the Texas Audit Privilege Law contained broad privilege and immunity provisions that compromised the ability of the Texas Natural Resource Conservation Commission to enforce the state's UIC program to protect drinking water. As a result of the enactment of this law, the Environmental Defense Fund and the Oil, Chemical, and Atomic Workers Union petitioned EPA to withdraw the Texas UIC Program.

Based on the petitions, Texas revised its statute to eliminate criminal amnesty and privilege. The revised statute also meets EPA's civil penalty criteria, provides the state with access to any information needed to verify compliance, and provides public access to information required to be made public under federal or state law. However, the revisions still allow limited-use immunity where (1) a violation has been corrected or the company is making prompt efforts to correct the violation, and (2) information not required to be collected, maintained, or reported is otherwise made available.

■ **Florida UIC Wells**. Florida disposes of secondary treated municipal effluent into Class I wells. The wells inject the waste into deep limestone formations below USDW. The federal UIC program and the state's newly revised rules require that the wells be constructed and operated to prevent the movement of any fluid into a USDW. Some wells in some locations have posed challenges to this standard as migration of this fluid has occurred, and EPA is working with the state and other stakeholders to evaluate alternative solutions. EPA is currently developing a proposed rule revision to address this issue only for the Class I municipal wells and only in South Florida. A rule proposal is anticipated in early 2000. Florida now requires that all Class V wells have a permit and meet state ground water standards, which include National Drinking Water Standards, at the point of injection. For aquifer storage and recovery (ASR) wells that use untreated water, EPA will work with the U.S. Army Corps of Engineers and other stakeholders to develop the parameters of the environmental impact statement for the Everglades study where ASR wells are used.

Public Education and Community Action

EPA developed a 15-minute video in which citizens and local officials in Great Falls, Virginia, Española, New Mexico, and Missoula, Montana, reveal how chemical waste discharged to ground water through shallow disposal systems contaminated their water resources and how it affected their communities. The video demonstrates that

- Shallow disposal systems are common, but often overlooked, sources of dangerous industrial chemicals
- Federal and state regulations are insufficient to control this kind of pollution in a community
- There are simple preventive steps a community can take to reduce this serious threat to its water supply without closing any businesses or going into financial debt.

EPA is distributing both English and Spanish versions of the video, primarily to tribal and local public health officials, public water systems, and community organizations, such as Chambers of Commerce and trade and professional associations, throughout the United States.

■ **Alabama Hydraulic Fracturing**. In 1997, the 11th Circuit Court of Appeals remanded a petition filed by the Legal Environmental Assistance Foundation (LEAF) for EPA to withdraw Alabama's UIC primacy. Alabama did not regulate hydraulic fracturing operations of coal beds for methane production under its program and, therefore, the petition maintained that Alabama was not fulfilling the UIC mandate to protect drinking water. EPA first attempted to collect additional data to assess any risks to drinking water posed by the practice. However, LEAF obtained a *Writ of Mandamus* and the court compelled EPA to begin withdrawal of Alabama's UIC program. Subsequently, Alabama passed new rules to regulate hydraulic fracturing and EPA formally approved the state rules as a

Ground Water Rule

EPA is developing a regulation on ground water that specifies the appropriate use of disinfection and addresses other components of ground water systems to ensure public health protection. Various studies seem to indicate that the number of ground water sources with evidence of fecal contamination is significant. EPA is analyzing the data to determine if they represent public wells nationally. The proposed rule also encourages the use of alternative approaches, including best management practices and source control.

program revision in December 1999. Withdrawal proceedings were then stopped.

Legal Challenges Relating to Federal Regulations

■ To satisfy the requirements under the SDWA and a modified consent decree with the Sierra Club, EPA published *Revisions to the Underground Injection Control Regulations for Class V Wells* in November 1999. EPA added new requirements for two types of high-risk Class V wells when located in source water protection areas that depend on ground water. These high-risk wells include large-capacity cesspools and motor vehicle waste disposal wells. EPA will be developing requirements for industrial waste disposal wells and the other subtypes of Class V wells in the near future.

UIC Tribal Program

■ The 1986 Amendments to the Safe Drinking Water Act allowed federally recognized tribes to be "Treated as a State" and to apply for primary enforcement authority (primacy) for the UIC Program. Injection wells operated on tribal lands are regulated by EPA if the tribe has not received primary enforcement authority in the UIC program. To date, no tribe has primacy for the program, although three tribes are actively developing programs (Mille Lacs Tribe in Minnesota, Fort Peck Tribe in Montana, and the Navajo Nation in Arizona, New Mexico, and Utah). A current initiative in the UIC tribal program is to improve inventory and management of Class V wells found on tribal lands.

EPA and states currently administer 57 UIC programs to maintain regulatory coverage of the large number of underground injection wells. Through regulatory development and research studies, EPA is actively promoting the protection of ground water quality.

Other Federal Programs

Underground storage tanks and solid and hazardous waste treatment, storage, and disposal are regulated under the Resource Conservation and Recovery Act and abandoned waste is regulated under the Comprehensive Environmental Response, Compensation, and Liability Act .

Two other important federal programs to protect our ground water are the Federal Insecticide, Fungicide, and Rodenticide Act and the Food Quality Protection Act (FQPA). Under FIFRA, EPA is responsible for registering new pesticides and reregistering older pesticides that were registered before current standards were developed. EPA must ensure that these pesticides will not cause unreasonable risk to human health or the environment when used according to label directions. FIFRA requires EPA to balance the risks of pesticide exposure on humans and the environment against the benefits of pesticide use to society and the economy. Under FQPA, EPA must consider human exposure to pesticides through the consumption of drinking water.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (1976) amended the Solid Waste Disposal Act. In 1984, the Hazardous and Solid Waste Amendments (HSWA) were passed by Congress, which greatly expanded the scope of the RCRA Program. Statutorily, the RCRA program has four major components.

Subtitle D	Solid Waste Program
Subtitle C	Hazardous Waste Program
Subtitle I	Underground Storage Tank Program
Subtitle J	Medical Waste Program (federal program expired*)

The intent of RCRA is to protect human health and the environment by establishing a comprehensive regulatory framework for investigating and addressing past, present, and future environmental contamination. This is done by identifying as hazardous those wastes that may pose hazards if improperly managed and establishing requirements for waste treatment and management to ultimate disposal. Specific goals of RCRA are as follows:

- To protect human health and the environment

- To reduce waste and conserve energy and natural resources

- To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

To ensure that the RCRA program is current in its mission to protect human health and the environment from hazards associated with waste management, the Agency has recently completed or has ongoing several activities that focus primarily on protection of ground water.

- EPA manages two major national information systems to support the RCRA Subtitle C Hazardous Waste program: the Resource Conservation and Recovery Information System (RCRIS) and the Biennial Reporting System (BRS). EPA began reinventing information management in the hazardous waste program in 1994 when the Office of Solid Waste (OSW) revised its strategic plan and identified new information management objectives. The Waste Information Needs (WIN) Initiative evolved from these objectives. EPA's WIN Initiative partnered with the states' Information Needs for Making Environmental Decisions (Informed) project. The joint WIN/Informed Initiative is an effort to reassess the information needed to run the hazardous waste program under RCRA. Some of the information covered by the project includes who is regulated, what is being regulated, and what kinds of activities and milestones must be tracked for the hazardous waste program. The Initiative seeks to improve data quality and meet the needs of EPA, states and tribes,

*The federal medical waste tracking program expired. It was a 2-year pilot program in response to the ocean washup of medical instruments along the East Coast during the summer of 1988. Several states have implemented their own medical waste tracking programs.

and public and private sector customers for timely and accurate information about hazardous waste management.

■ EPA released for public comment a list of 53 persistent, bioaccumulative, and toxic (PBT) chemicals and chemical categories that may be found in hazardous wastes regulated under RCRA. This list is a response to states, industry organizations, environmental groups, and individuals who commented on EPA's national RCRA waste minimization policy, and it will be used to promote voluntary waste minimization efforts that reduce the generation of PBT chemicals found in RCRA hazardous waste by at least half by the year 2005.

■ Under the Hazardous Waste Identification Final Rule (HWIR) for Contaminated Media, EPA is issuing new requirements for hazardous remediation wastes treated, stored, or disposed of during cleanup actions. These new requirements make five major changes: (1) they make permits for treating, storing, and disposing of remediation wastes faster and easier to obtain; (2) they provide that obtaining these permits will not subject the owner and/or operator to facility-wide corrective action; (3) they create a new kind of unit called a "staging pile" that allows more flexibility in storing remediation waste during cleanup; (4) they exclude dredged materials from RCRA Subtitle C if they are managed under an appropriate permit under the Marine Protection, Research and Sanctuaries Act or the Clean Water Act; and (5) they make it faster and easier for states to receive authorization when they update their RCRA programs to incorporate revisions to the federal RCRA regulations.

■ As part of the Hazardous Waste Identification Rule for Waste, EPA is developing cutting-edge risk assessment modeling work that addresses the fate and transport of contaminants in the ground water environment through the use of a more accurate ground water model (as well as assesses risks posed by other release pathways). These models were used in the December 1995 HWIR-waste proposal to evaluate risks from approximately 200 hazardous waste constituents.

■ EPA is evaluating important aspects of and potentially improving the Land Disposal Restrictions (LDR) Program. EPA's overall goal in the LDR reinvention project is to examine the best way to ensure the program is environmentally protective, less expensive, more efficient and flexible, clearer to the public, and more enforceable.

Underground Storage Tank Program

The Underground Storage Tank Program falls under RCRA. One of the primary goals of this program is to protect the nation's ground water resources from releases by underground storage tanks (USTs) containing petroleum or certain hazardous substances. EPA works with state and local governments to implement federal requirements for proper management of USTs. As of March 1999, EPA estimates that about 825,000 federally regulated USTs are buried at more than 300,000 sites nationwide. Nearly all

USTs contain petroleum—about 25,000 USTs hold hazardous waste covered by federal regulations.

In 1988, EPA issued regulations setting minimum standards for new tanks (those installed after December 22, 1988) and existing tanks (those installed before December 22, 1988). During the next 10 years (by December 1998), existing USTs were required to be upgraded to meet minimum standards, be replaced with new tanks, or be closed properly. Since 1988, more than 1.3 million old USTs have been closed, thus eliminating a significant number of potential sources of ground water contamination. The vast majority of USTs have complied with the December 1998 requirements. EPA and the states are continuing to work to ensure full compliance.

New and existing USTs complying with EPA's standards can prevent leaks caused by spills, overfills, corrosion, and faulty installation. Compliance with the leak detection requirements also can prevent releases from USTs before contamination spreads. Corrective action requirements ensure responsible and timely cleanup of contaminated sites.

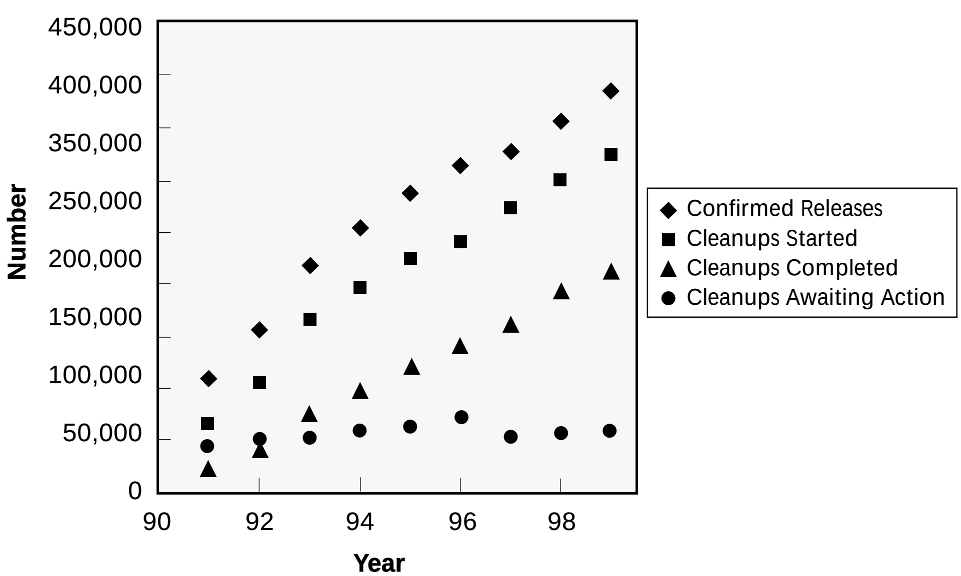
As of March 1999, more than 385,000 UST releases had been confirmed. EPA estimates that about half of these releases have reached ground water. Ground water impacts include the presence of well-documented contaminants, such as benzene, toluene, ethyl benzene, and xylene (BTEX). Also, ground water contamination from methyl tert-butyl ether (MTBE) has become a significant concern in some areas. Remediation decisions involving MTBE can differ from those involving BTEX, often requiring more expensive and extensive cleanups.

About 210,000 contaminated sites have been cleaned up, and cleanups are in progress at 115,000 more sites (Figure 25). EPA estimates that the total number of confirmed releases will surpass 400,000 in the next year, primarily releases discovered during the closure or replacement of the remaining USTs. EPA expects the number of new releases to begin to decrease now that most UST systems are equipped with leak prevention and detection.

Congress created the Leaking Underground Storage Tank (LUST) Trust Fund in 1986 to provide money for overseeing corrective action taken by a responsible party and to provide money for cleanups at UST sites where the owner or

Figure 25

Status of Cleanup at UST Sites



operator is unknown, unwilling, or unable to respond or that require emergency action. Since 1986, $677 million has been dispersed to state UST programs for state officials to use for administration, oversight, and cleanup work.

UST owners and operators must also meet financial responsibility requirements that ensure that they will have the resources to pay for costs associated with cleaning up releases and compensating third parties. The amount of coverage required ranges from $500,000 to $1 million per occurrence, according to the type and size of the UST business. Many states have provided financial assurance funds to help their UST owners meet the financial responsibility requirements. These state funds included more than $1.3 billion in 1998 for use on UST cleanups.

EPA recognizes that, because of the large size and great diversity of the regulated community, state and local governments are in the best position to oversee USTs. EPA encourages states to seek State Program Approval so they may operate in lieu of the federal program. So far, 27 states, the District of Columbia, and Puerto Rico have received State Program Approval. All states have UST regulations and programs in place. The Agency also has developed a data management system that many states use to track the status of UST facilities, including their impact on ground water resources. EPA also has negotiated UST grants with all states and provided technical assistance and guidance for implementation and enforcement of UST regulations.

Comprehensive Environmental, Response, Compensation, and Liability Act (Superfund Program)

In the late 1970s, a series of headline stories alerted the United States to the dangers of dumping, burying, or improperly storing hazardous waste. The magnitude of uncontrolled disposal of hazardous waste moved Congress to pass the Comprehensive Environmental, Response, Compensation, and Liability Act in 1980. CERCLA, commonly known as Superfund, was the first comprehensive federal law designed specifically to deal with the dangers posed by the nation's abandoned and uncontrolled hazardous waste sites. EPA's mission under Superfund is to

- Protect human health and the environment from uncontrolled hazardous releases
- Study, design, and construct long-term solutions for the nation's most serious hazardous waste problems
- Require parties responsible for contamination to pay for site cleanup.

It is difficult to describe the "typical" hazardous waste site because they are so diverse, and many sites have had multiple uses in the past. Many sites are municipal or industrial landfills; others are manufacturing plants where operators improperly disposed of wastes. Some sites are large federal facilities with "hot spots" of contamination resulting from various high-tech or military activities. Although Superfund's hazardous waste sites have been abandoned, they may exist in active industrial or commercial areas. In general, landfills are the most common Superfund sites, followed by chemical and metals manufacturing and recycling operations.

The type of contamination resulting from past site activities can also vary widely. Some of the most frequently found contaminant classes at Superfund sites are heavy metals, such as lead and mercury, volatile organic compounds, polychlorinated biphenyls (PCBs), pesticides and herbicides, and creosotes. These contaminants can have adverse effects on human health ranging from breathing difficulties to developmental and learning disorders and chronic health conditions such as cancer. They also pose a threat to ecosystems by indirectly or directly affecting the ability of animals and plants to survive and reproduce. EPA is working to determine appropriate site outcomes and allay concerns about human health threats.

Because so many hazardous waste sites exist throughout the nation, EPA must identify and prioritize the most serious sites for long-term cleanup actions under the Superfund program. EPA uses a mathematical scoring system called the Hazard Ranking System (HRS) to assess the relative risks posed by sites to determine whether a site is eligible for placement on the National Priorities List (NPL). A site's HRS score is based on the likelihood that a hazardous substance will be released from the site, the toxicity and amount of hazardous substances at the site, and the location of populations potentially affected by the contamination at the site.

EPA uses the NPL to track the Superfund Program's progress in characterizing and cleaning up the listed sites. Administrative reforms have significantly increased the pace and lowered the cost of site cleanups. Almost three times as many Superfund sites have had construction completed in the past 6 years than in all of the prior years of the program combined. As of September 30, 1998, more than 89% of nonfederal sites on the final NPL are either undergoing cleanup construction (remedial or removal) or are completed:

- 585 Superfund sites have reached construction completion (41% of the sites on the NPL) and 457 Superfund sites (32% of the sites on the NPL) have cleanup construction under way.

- 209 sites (15% of the sites on the NPL) have had or are undergoing a removal cleanup action.

- Approximately 990 NPL sites have final cleanup plans approved.

- Approximately 5,500 removal actions have been taken at hazardous waste sites to immediately reduce the threat to public health and the environment. Responsible parties continue to perform approximately 70% of new remedial work at NPL sites, and more than 30,900 sites have been removed from the Superfund inventory of potentially hazardous waste sites to help promote the economic redevelopment of these properties.

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Rocky Mountain Arsenal — Colorado

Years of Army weapons production and industrial manufacture of chemicals for pesticides, insecticides, and herbicides resulted in contaminated soil, sediment, and water at the Rocky Mountain Arsenal site, 10 miles northeast of downtown Denver, Colorado. For decades, the Army and private chemical manufacturers disposed of liquid wastes in numerous unlined waste disposal basins and trenches, which allowed the waste to reach the ground water. By 1995, nearby residents noticed crop damage and voiced concern about contaminated ground water. Since the mid-1970s, the Army and other responsible parties have been jointly investigating and cleaning up the contamination at the site, which is one of the largest environmental cleanup sites in the nation.

More than half of the 31 cleanup projects were either in the design or construction phase during 1999. In 1998, a total of 33 contractors worked on cleanup activities and additional contractors were hired in 1999. EPA, the Colorado Department of Health and Environment, and the Tri-County Health Department continue to provide invaluable service to the Arsenal and the community in the completion of the Arsenal's cleanup and the vision of it as one of the largest, urban national wildlife refuges.

Studies during the 1970s identified on-post areas with varying degrees of contamination, including buildings, soil, ditches, stream and lake bed sediments, sewers, ground water, surface water, and off-post ground water. The most highly contaminated soils are located in the central 6 square miles of the Arsenal, which contain the manufacturing and waste disposal areas, including waste disposal landfills and basins. A chemical, diisopropyl-methylphosphanate (DIMP, a byproduct of nerve gas production), pesticides, solvents, arsenic, fluoride, and chloride contaminate ground water on the post. EPA added most of the Arsenal to its National Priorities List in July 1987.

Several activities at the site are planned or have been completed to help clean up ground water and provide quality drinking water to area residents in the future, including:

- Continued operation of the on-post and off-post ground water treatment systems and evaluation of these systems every 5 years
- Provision of $48.8 million to acquire and deliver additional water to the South Adams County Water and Sanitation District and to furnish drinking water to Henderson city residents whose wells are contaminated with DIMP

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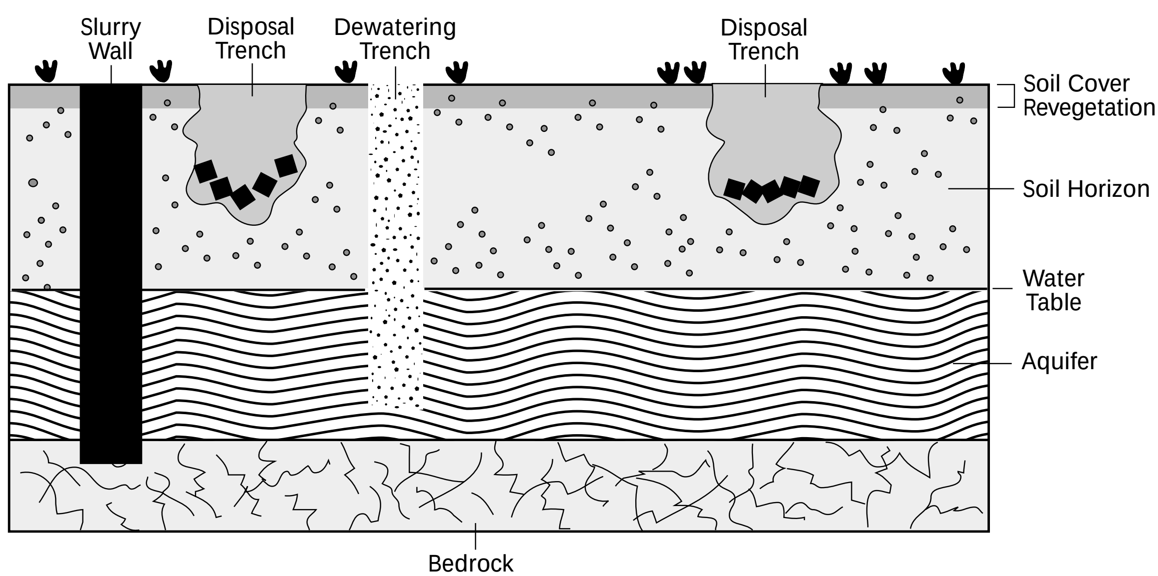
■ Installation of a slurry wall around the Arsenal Complex and construction of disposal trenches to minimize contact between ground water and waste materials left in place

■ Construction of a RCRA-equivalent cap with a wildlife barrier over the area

■ Construction of an on-post, double-lined, hazardous waste landfill covering 24 acres to accept millions of tons of material from 18 of the Arsenal's cleanup projects.

Construction on several of these key on-post projects began in 1998 and continued into 1999. The coming years will provide evidence that a successful cleanup effort can be accomplished with cooperation and vision of state, local, and federal governments and the involvement of many people from the surrounding community. Through this vision, a true environmental accomplishment can evolve and become one of the largest, urban national wildlife refuges.



Rocky Mountain Arsenal Complex

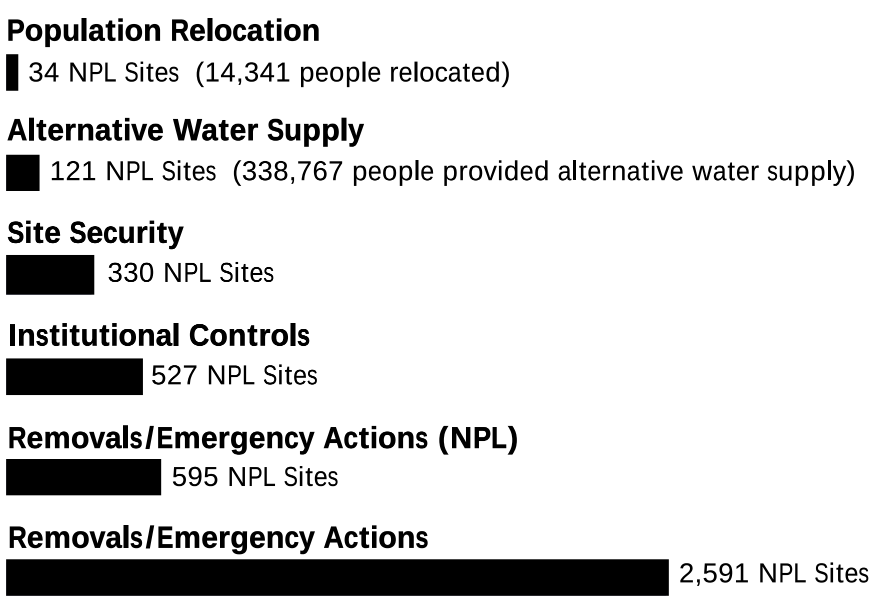
NPL sites are a subset of a larger Superfund inventory of hazardous waste sites that also includes non-NPL sites and sites that have no further remedial action planned (NFRAP). Non-NPL sites pose health and environmental risks that can be addressed through short-term actions and do not always require the complex cleanup actions needed at NPL sites. There are currently 39,783 non-NPL sites that Superfund has assessed. Of these sites, 9,245 remain active and 30,438 have been archived as NFRAP sites.

There are 60 million people living within 4 miles of NPL sites.

Figure 26

Short-Term Actions Taken at Sites to Protect Human Health and the Environment

1980 to June 1997



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Living near a site does not automatically place a person at risk—it depends on the amount and toxicity of contaminants present and if a person comes in contact with them (e.g., drinking contaminated water or breathing contaminated air). EPA performs human health and ecological risk assessments to determine the amounts and types of chemicals being released, the pathways of exposure to these chemicals, and the threats these chemicals pose to human health and the environment. EPA compiles data on human health and ecological risks through site investigations, field sampling, and historical research. These risk assessments are conducted to facilitate risk management decisions, determine long-term cleanup goals, and ensure that the selected cleanup remedy will offer protection to the public and surrounding ecosystems.

The Superfund Program's mission requires addressing both immediate threats to populations living near hazardous waste sites and long-term cleanup actions at these sites. To address immediate threats, short-term actions are often taken to control critical situations and ensure the safety of communities until long-term actions can remove or permanently clean up hazardous contamination (Figure 26). Since inception, the Superfund program has supplied more than 300,000 people with alternative water supplies to protect them from contaminated ground water and surface water. In addition, more than 14,000 people have been relocated where contamination posed the most severe immediate threats. To prohibit certain types of land uses at sites, institutional controls such as deed and fishing restrictions have been implemented at more than 500 NPL sites. Site security measures, such as fencing and guards, to restrict access have been implemented at more than 300 NPL sites. To ensure the safety of the surrounding community from critical emergencies caused by hazardous waste, 1,263 removals of wastes were completed at approximately 600 NPL sites and 2,897 removals of hazardous substances were completed at more than 2,500 non-NPL sites.

At most NPL sites, complex long-term remedial actions are also needed to clean up contaminants. A key aspect of the cleanup process is determining which technology is appropriate. Superfund managers analyze the types and amounts of hazardous waste contamination to determine the best method to restore the affected area to designated cleanup levels. Cleanup technologies generally fall into the "containment" or "treatment" category. Containment technologies create a physical barrier, holding the contamination in place to protect the public from direct contact. An example of a containment technology is capping, which involves constructing a protective barrier over contaminated soil, solid waste, or sediment. Treatment, on the other hand, reduces the toxicity, mobility, and/or volume of wastes found at sites.

Because hazardous waste pollutes soils, seeps into ground water, and runs off into surface water, EPA uses a "divide and conquer" approach that involves organizing a site into distinct cleanup efforts and then setting cleanup goals for each specific area of contamination (land, ground water, and surface water). The Superfund Program has cleaned over 132 million cubic yards of hazardous soil, solid waste, and sediment and over 341 billion gallons of hazardous liquid-based waste, ground water, and surface water.

States and tribes are key partners in the cleanup of Superfund hazardous waste sites. With the May 1998 release of *Plan to Enhance the Role of States and Tribes in the Superfund Program*, the Superfund Program has provided opportunities for increased state and tribal involvement. As a result, 14 pilot projects with states and tribes have been initiated.

The Superfund Program is also committed to continuing to involve citizens in the site cleanup process. EPA strives to create a decision-making process to clean up sites that the communities feel is open and legitimate and improves the community's understanding of the potential health risks at hazardous waste sites. This is accomplished through

- Outreach efforts, such as holding public meetings and establishing community advisory groups, restoration advisory boards, or site-specific advisory boards

- Providing communities with financial assistance to hire technical consultants to assist them in understanding the problems and potential solutions to the contamination problems

- Distributing site-specific fact sheets.

Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA was passed by Congress in 1947 and amended in 1988 to accelerate the progress of pesticide reregistration. Pesticides can enter ground water through pesticide spills, improper storage or disposal, poorly sealed wells, or as a result of normal application to farmlands and lawns. When pesticides contaminate ground water, there is a potential risk to the health of those who drink and use the water. In 1992, the Agency's *Pesticides in Ground Water Database* showed that 132 pesticides had been found in ground water in 42 states. The majority of these samples (93%) were taken from drinking water wells.

One of the goals of FIFRA is to protect human health and the environment from the risks of pesticide use. Several programs have been undertaken by EPA to protect ground water from pesticide contamination. These include the Pesticide Management Plan (PMP), Reduced Risk Products, and the Registration/Reregistration Programs.

Ground Water and Pesticides Management Plans (PMP)

EPA's Office of Pesticide Programs (OPP) has been providing cooperative agreement support for voluntary state and tribal pesticide management plans since 1991. In response to the development of EPA's 1991 policy document, *Protecting the Nation's Ground Water: EPA's Strategy for the 1990s*, OPP, in conjunction with its stakeholders, prepared its own *Pesticides and Ground Water Strategy* later that year. The heart of the strategy is a pesticide management program based on the concepts of prevention and local action. This approach is a departure from the traditional pesticide registration process in which national level restrictions are placed on a product label as a condition of use. Under the PMP concept, states and tribes wishing to continue use of chemicals of concern are required to prepare a prevention plan that targets specific areas vulnerable to ground water contamination based on actual conditions of pesticide use and the relative risks associated with the local hydrogeology. Plans are to be developed in a public process that allows those affected to examine the use, value, and vulnerability of the resource, taking into consideration economic and social values. PMPs are designed to be flexible, allowing states and tribes to adjust them in accordance with changing risk conditions, market trends, and program experience. Throughout the process, the public is kept informed of program status and emerging environmental trends. As long as a state or tribe manages its PMP so as to avoid the likelihood of unreasonable adverse effects to human health or the environment, it can maintain its PMP approval status and continue to use these chemicals of concern. Currently, OPP is seeking to restrict (through rule-making) four widely used herbicides (atrazine, cynazine, alachlor, and metolachlor) that have been shown to leach to ground water readily and to persist in the environment. This rule would also provide for the inclusion of any degradates of concern or other registered chemicals that merit restriction due to ground water concerns.

Registration Process and Reduced Risk Products

Reduced risk pesticides fall into two categories: conventional and biological. The conventional reduced risk pesticides have low potential for ground water contamination, lower toxicity than other pesticides, and other important characteristics that make them less harmful to the environment. Four of these pesticides were registered in 1997; another two were registered in 1998. These include reduced-risk fungicides, herbicides, and insecticides for a variety of crop and noncrop uses.

Biological pesticides are based on naturally occurring substances; therefore, they generally pose less risk to human health and the environment than conventional pesticides. Examples include microbial pesticides (bacteria, viruses, or other microorganisms used to control pests) and biochemical pesticides such as pheromones (insect mating attractants), insect and plant growth regulators, and hormones. Most biological pesticides are applied at very low rates or are applied in bait, trap, or “encapsulated” formulations and thus result in less exposure and less likelihood of adverse effects to humans and the environment. EPA has registered 37 new biological pesticides. Among these new pesticides are the first “plant pesticide” products. Plant pesticides are altered agricultural plants that produce proteins that are toxic to crop-destroying insects.

Reregistration Process

EPA must review the human health and environmental effects of all pesticides registered before November 1, 1984, to determine whether they meet today’s standards. If a pesticide has been found in ground water or has the potential to contaminate ground water, various mitigation measures are recommended to control the contamination. These can include a variety of measures such as advisories on the label regarding a pesticide’s potential to contaminate ground water, restricted use (requiring that only certified applicators can apply the pesticide), limitations on the types of soils to which it can be applied, reductions in the application rate, and cancellation of certain uses.

Special Review

A Special Review is conducted on a pesticide when EPA believes it creates an unacceptable risk to human health or the environment. A number of the pesticides undergoing the Special Review process are ground water contaminants, including atrazine, aldicarb, and alachlor. EPA has taken measures to reduce this contamination through a number of measures including voluntary cancellation of uses or restrictions for application on certain types of soils.

Food Quality Protection Act

The FQPA was signed into law in 1996. FQPA amended FIFRA to ensure that all pesticides would meet new safety standards. As a result of FQPA, EPA must now consider human exposure to pesticides from drinking water as well as food and home uses. The law states that more than 9,000 pesticide uses must be assessed by August 2006. EPA has developed an interim approach for addressing exposure to pesticides from drinking water that uses modeling as a screening tool. Although information on pesticides in ground water would be more useful, comprehensive monitoring information is not readily available for many pesticides. At present, EPA's Office of Pesticide Programs is developing a new comprehensive electronic database that will summarize ground water monitoring information in the United States. The monitoring information in this database will be used by federal, state, and local agencies to help protect ground water from pesticide contamination.

Conclusion and Findings

Experience in the 305(b) program shows vast differences in the level of sophistication characterizing state ground water protection efforts. These differences are most frequently attributed to differences in state priorities and allocation of resources. Some states have implemented intensive efforts aimed at characterizing ground water quality and identifying and addressing threats to ground water. In contrast, some states at the other end of the spectrum are only just now beginning to implement ground water protection strategies.

Despite these differences, there is an overall trend nationwide to preserve the quality of our nation's ground water resources. Clearly, all reporting states, territories, and tribes recognize the importance of their ground water resources and are intent on protecting them.

One especially strong trend that was evidenced in the 1998 305(b) reports was an emphasis on delineating hydrogeologic monitoring units (e.g., aquifers) as a first step in ground water protection efforts. States provided detailed descriptions of the methodologies they used to delineate hydrogeologic monitoring units and their monitoring rationale. Frequently, detailed maps depicting the monitoring units were provided along with characterization of ground water quality in the monitored units. States reported that they collect ground water monitoring data to

- Identify temporal and spatial trends in ground water quality
- Identify and track ground water contamination problems
- Prioritize and emphasize different aspects of protection programs
- Develop programs aimed at remediation of existing contamination problems or prevention of future problems
- Evaluate overall program effectiveness.

Obviously, ground water monitoring is an important component of any protection strategy. But just as important is how a state manages and uses the data they collect. There is no doubt that ground water monitoring is expensive.

Hence, it is not surprising that an important trend observed in 1998 was the use of monitoring results to streamline and focus state ground water programs. This was especially true when a state was faced with limited financial resources. In these cases, states prioritized their efforts by first protecting their most valuable and vulnerable resources. Typically, states work either to control specific sources of ground water contamination or to control activities that may contribute to ground water contamination. Effective state programs include

- Strict technical controls such as a discharge permit program

- Strict controls on sources of point and nonpoint source contamination (e.g., programs that address leaking underground storage tanks or widespread application of pesticide and/or fertilizer)

- Implementation of best management practices

- Formulation of antidegradation policies

- Development of ground water quality standards.

Although these program components are common to most state protection strategies, it is important to recognize that conditions, demands for ground water, and prioritizations vary from the east coast to the west coast. In response to their specific needs, states promulgate protection regulations that are unique to their conditions and/or contamination challenges. For example, Wyoming's protection strategy includes the requirement that chemigation wells have backflow protection, Indiana has developed a program for bulk storage of agricultural chemicals, and Nevada is developing a chemical accident prevention program. Nearly all states in the nation have implemented some component of protection that is unique to them.

With all these new developments, communication takes on an increasingly important role. In most states, ground water is protected under multiple state and federal programs; as a consequence, multiple agencies are involved in ground water protection activities. If communication between these agencies is lacking or inefficient, redundancies or deficiencies in ground water protection efforts may occur. Because, historically, data management has been a limiting factor in monitoring ground water quality, an important trend is the strengthening of communication and data sharing between agencies. States are making a concerted effort to address communication problems and enhance coordination among agencies. Actions include:

- Development of advisory committees that include representatives from state, federal, and private industry

- Development of comprehensive data management systems to enhance data sharing

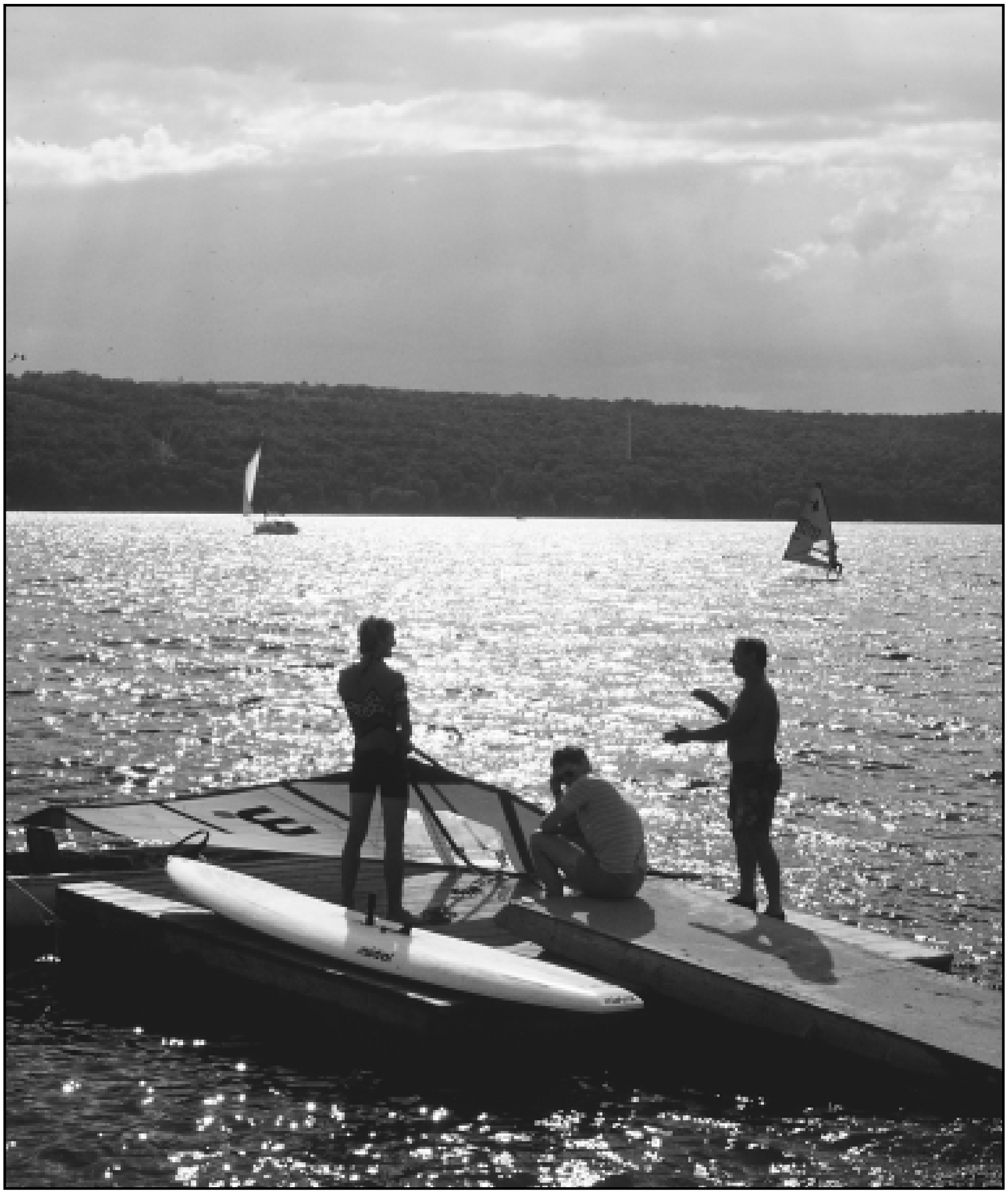
- Use of the World Wide Web (Internet) to enhance data availability and communication

- Use of modern system technologies such as GIS to display and evaluate data spatially

- Use of management tools by state environmental managers in making planning decisions and implementing long-term pollution prevention policies.

One of the most important trends in the enhancement of communication is the increasing use of modern system technologies like GIS. States report that they are developing coverages depicting monitored hydrologic units, monitoring well locations, contaminant levels in individual wells, and point sources of potential contamination. As each successive layer is added, threats to ground water quality are identified and addressed as part of an overall ground water protection strategy. Communication is enhanced as respective agencies step forward to review the use of their data and make suggestions to improve interpretations.

The value and importance of ground water have been recognized across the nation by the states reporting monitoring data through the 305(b) program. Every state in the nation is taking important steps to preserve and protect our nation's ground water resources.



John McShane, Cayuga Lake, Ithaca, NY

Drinking Water Quality Programs

Drinking Water Source Assessments

The Safe Drinking Water Act (SDWA) calls for states to determine the susceptibility of waters to contamination, while Section 305(b) of the Clean Water Act calls for them to assess the ability of waters to support drinking water use. States may prioritize their water resources and perform drinking water use support assessments for a limited percentage of their water resources. They are then encouraged to expand their drinking water assessment efforts to include additional waters at each subsequent reporting cycle. EPA recommends prioritization based on waters of greatest drinking water demand, with further prioritization with respect to vulnerability or other state priority factors. In addition, states are encouraged to use a tiered approach in the assessment. This tiered approach accommodates the different types of data currently available to states and allows for differing levels of assessment.

States use the general criteria outlined in Table 10 to determine the degree of drinking water use support for waterbodies in their state. These criteria may be modified by the states to fit their individual situations.

Table 10. Criteria to Determine Drinking Water Use Support

Classification	Monitoring Data		Use Support Restrictions
Full support	Contaminants do not exceed water quality criteria	and/or	Drinking water use restrictions are not in effect
Full support but threatened	Contaminants are detected but do not exceed water quality criteria	and/or	Some drinking water use restrictions have occurred and/or the potential for adverse impacts to source water quality exists
Partial support	Contaminants exceed water quality criteria intermittently	and/or	Drinking water use restrictions resulted in the need for more than conventional treatment
Nonsupport	Contaminants exceed water quality criteria consistently	and/or	Drinking water use restrictions resulted in closures
Unassessed	Source water quality has not been assessed		

Summary of State Drinking Water Assessments

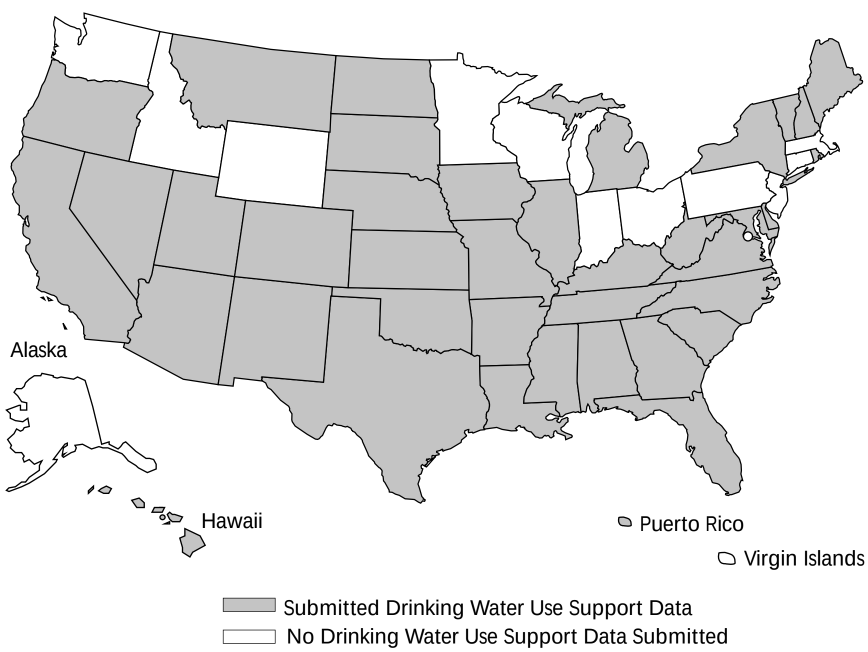
Thirty-eight states, tribes, or territories submitted drinking water use data in their reports. Figure 27 shows which states submitted drinking water data for rivers and streams and/or lakes and reservoirs. Table 11 shows the total number of miles of rivers and streams and acres of lakes and reservoirs assessed and the degree of drinking water use support for the entire nation. The majority of waterbodies assessed, 87% of rivers and streams and 82% of lakes and reservoirs, are fully supporting of drinking water use. Only 3% of assessed rivers and streams and 5% of lakes and reservoirs do not support drinking water use.

A large improvement was seen between the drinking water use support data reported by the states in the 1998 305(b) report and that reported previously. In the early 1990s, only a small percentage of rivers, streams, lakes, and reservoirs were assessed for drinking water use. In 1998, more states reported on how they classified waterbodies for drinking water use and on sources of water contamination. The increased data resulted in a more accurate framework for assessing drinking water use support in the nation.

However, 12 states did not report data on drinking water use support. Many of the 38 states that reported data did not present any information on how they classified their waterbodies for drinking water use support or on sources of water contamination. This lack of information complicates data interpretation and presents challenges for accurately assessing and representing drinking water use support.

Figure 27

States Submitting Drinking Water Use Support Data in Their 305(b) Reports



Source: 1998 305(b) reports submitted by states.

Sources of Drinking Water Use Impairment

Each state analyzed for contaminants of concern to them, and used different criteria for assessing drinking water use impairment. In addition, many states did not identify the particular contaminants that caused drinking water use impairment. Thus, it is not possible to present quantitative data on this issue. However, based on the limited number of states identifying contaminants, Table 12 summarizes all of the contaminants cited as causing drinking water use impairment.

Ensuring Safe Drinking Water

Thanks to decades of effort by public and private organizations and the enactment of drinking water legislation, most Americans can turn on their taps without fear of receiving unsafe water. Ensuring consistently safe drinking water requires the cooperation of federal, state, tribal, and municipal governments to protect the water as it moves through three stages of the system—the raw source water, the water treatment plant, and the pipes that deliver finished water to consumers' taps. Polluted source waters greatly increase the level and expense of treatment needed to provide finished water that meets public health standards.

The passage of the SDWA Amendments of 1996 brought substantial changes to the national drinking water program for water utilities, states, and EPA, as well as greater protection and information to the 250 million Americans served by public water systems.

Source Water Protection

The SDWA Amendments establish a strong new emphasis on preventing contamination problems through source water protection and enhanced water system management. The states are central in creating and focusing prevention programs and helping water systems improve their operations to avoid contamination problems. States are assessing the susceptibility to contamination of the source waters supplying public water systems. These assessments will provide the information necessary for states to develop tailored monitoring programs and for water systems to seek help from states in protecting source water or initiating local government efforts. Every state took advantage of the opportunity to use a portion of the Drinking Water State Revolving Fund to initiate source water assessments in FY 97.

To emphasize its commitment to source water protection, EPA included a source water protection goal in *Environmental Goals for America With Milestones for 2005*, which was originally released in

Table 11. National Drinking Water Use Support

	Fully Supporting	Threatened	Partially Supporting	Not Supporting	Total Assessed
Rivers and Streams					
Miles	122,318	5,844	8,164	4,616	140,954
Percentage	87	4	6	3	—
Lakes and Reservoirs					
Acres	6,926,031	303,374	794,573	394,307	8,418,286
Percentage	82	4	9	5	—

Table 12. Sources of Drinking Water Use Impairment

Contaminant Group	Specific Contaminant	
Pesticides	Atrazine Metolachlor Triazine	Molinate Ethylene dibromide
Volatile organic chemicals	Trichloroethylene Tetrachloroethylene 1,1,1-Trichloroethane *cis*-1,2-Dichloroethylene Trihalomethanes Carbon tetrachloride Ethylbenzene 1,1,2,2-Tetrachloroethane	Dichloromethane 1,1-Dichloroethane 1,1-Dichloroethylene Toluene Benzene Dichlorobenzene Methyl(tert)butyl ether Xylene
Inorganic chemicals	Arsenic Nitrates Iron Copper Chloride	Fluoride Manganese Lead Sodium
Microbiological contaminants	Exceedance of total coliform rule	Exceedance of fecal coliform rule

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Protecting Sources of Drinking Water

Introduction

In the United States today, approximately 11,000 community water systems serving over 160 million people rely on lakes, reservoirs, and rivers as their main sources of drinking water. There is a growing recognition that addressing the quality and protection of these water sources can prevent contamination, thus reducing costly additional treatment and cleanup. Across the country, drinking water utilities are engaged in innovative and successful source water protection programs. These programs rely heavily on partnerships with local governments and often involve working closely with watershed councils, entering into land exchange agreements with land management agencies, and engaging with local farmers to implement best management practices aimed at protecting sources of drinking water.

The local actions that help protect sources of drinking water can generally be classified as: (1) creating partnerships, (2) assessing watersheds, (3) managing land use in watersheds, and (4) acquiring land.

Creating Partnerships

Instituting drinking water protection with a source water protection program involves balancing competing interests and conflicting demands within the watershed. This can be done through watershed planning committees or simply by establishing good, long-term relationships among the partners, which encourages a level playing field for reconciling the community's needs. It is important for affected parties—water utilities, local and state governments, watershed councils, nongovernment organizations, and others—to share information effectively.

Example: Creating Partnerships with Groups and Individuals, Chester Water Authority, Chester, Pennsylvania

To protect the water quality of its Octoraro Reservoir, the Chester Water Authority has forged a strong and lasting partnership with the Octoraro Watershed Association. This partnership bridges the gap between the citizens who get their drinking water from the Octoraro

Reservoir but do not live in the watershed and the farmers and landowners who live in the watershed but do not get their drinking water from the reservoir. The Chester Water Authority and the Octoraro Watershed Association have jointly supported many education and outreach programs, and the Authority has provided a meeting place and administrative support services to the Association. The Association promotes agricultural best management practices (BMPs) such as streambank fencing, barnyard management, crop rotation, and the establishment of forested riparian buffers throughout the watershed. One of the Association's greatest challenges has been convincing farmers that the BMPs will benefit both them and the watershed. Sharing success stories is often a successful way to garner support for BMP implementation. The Association also helps willing farmers seek financial aid for their BMPs. Funds are often available from local, state, and federal partners.

Assessing Watersheds

One of the keys to a strong watershed protection program is the assessment of the area. It is important to be able to identify watershed problems and target protection efforts. Watershed delineation and assessment are tools used to achieve these goals. Many water utilities use geographic information systems (GIS) to delineate their watersheds. Afterwards, local managers can use zoning maps to identify land use patterns within the watersheds and identify potential sources of contamination that pose the greatest threats to the drinking water supply. A comprehensive monitoring plan is also useful for identifying watershed problems.

***Example*: Monitoring Data to Support Protective Water Quality Standards, Portland Water Bureau, Portland, Oregon**

The Portland Water Bureau draws its water from the Bull Run River in the Mt. Hood National Forest. The U.S. Forest Service (USFS) administers the watershed under several legal authorities including the Bull Run Management Act (P.L. 95-200). This act sets the production of pure, clean, raw, potable

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water as the principal federal management objective for the area. Consequently, the USFS must adopt standards specific to the Bull Run watershed that are more stringent than its national standards. The USFS, the Portland Water Bureau, and the U.S. Geological Survey share the monitoring responsibilities of sampling, data collection and analysis, and database management. Monitoring is critical to unfiltered water systems, serving as an early warning of turbidity-producing events such as landslides and storm-induced erosion. By tracking turbidity levels during and after these events, facility operators can either divert heavily contaminated waters or temporarily switch to an alternative ground water source. The Portland Water Bureau is also using the monitoring program to estimate the sediment loading from abandoned roads in the national forest.

Managing Land Use in Watersheds

The type of land use in a drinking water supply source area, whether it is rural, urban, forested, and/or farmed, presents a challenge to managing the water source. Utilities whose water sources are in a forested area usually must contend with logging, erosion, and timber management. Systems whose sources are in rural or suburban areas may need to deal with septic systems, agricultural runoff, and erosion or recreational uses such as swimming, hiking, and mountain biking. In urban areas, utilities need to address issues such as storm water drainage, runoff from pavement, and increasing development. Solutions to the pollution from these various land uses range from simple, creative ideas that other systems can easily adopt, to capital-intensive projects that require significant funding commitments.

Example: Managing Urban Storm Water, Massachusetts Water Resources Authority, Boston, Massachusetts

Pollutant runoff from construction sites after large rainfall events can stress drinking water treatment facilities. Although the Massachusetts Water Resources Authority does not regulate storm water releases from construction sites, the Metropolitan District Commission (MDC) Division of Watershed Management works with petitioners to review all plans for the design and construction of storm water and erosion control projects. These control projects are required under the state's Watershed Protection Act and Wetlands Protection Act. In addition to reviewing plans, annual watershed sanitary surveys help MDC staff identify areas of concern. Once a specific threat to human health is identified, the MDC works with the responsible party to mitigate the situation. In the future, MDC plans to analyze pollutant loading at the subbasin level and recommend

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BMPs. The Massachusetts Water Resources Authority and MDC plan to conduct workshops to help municipalities implement the BMPs and may provide technical and financial assistance.

Acquiring Land

One way to solve the problem of competing land uses within a watershed is to acquire all the land surrounding a water source. Rather than negotiate with individual landowners, the system buys the land surrounding a surface water source. This solution is simple, yet often difficult to implement.

Example: Land Acquisition Program Targets High-Priority Parcels, New York City Department of Environmental Protection, New York, New York

New York City's water utility, the Department of Environmental Protection (DEP), has embarked on a 10-year program of land acquisition within its watersheds. DEP has committed $250 million to acquire property associated with the Catskill and Delaware River supply systems. These supplies spread over 1,600 square miles west of the Hudson River and provide 90% of New York City's water. An additional $10 million has been set aside for the same purpose in the Croton Watershed, which lies east of the Hudson. This program operates under a 10-year water supply permit from the New York State Department of Environmental Conservation (NYSDEC) issued in 1997. This permit enables DEP to acquire, through purchase or conservation easements, undeveloped land near reservoirs, wetlands, and watercourses, as well as land with other features sensitive to water quality. No land will be taken through eminent domain, and fair market value is paid for all land. The watersheds have been divided into priority areas for acquisition, based on natural features and proximity to reservoirs, intakes, and DEP's distribution system.

Conclusions

The examples provided here are just a sampling of local actions being taken across the country to protect sources of drinking water. The common thread among the examples is the coordination of a drinking water utility's goals with local watershed management initiatives aimed at aquatic ecosystem restoration and protection.

This highlight was drawn from *Protecting Sources of Drinking Water: Selected Case Studies in Watershed Management* (EPA 816-R-98-019, April 1999). For more information on EPA's efforts to protect drinking water sources, visit the Office of Ground Water and Drinking Water on the Internet at *http://www.epa.gov/ogwdw/protect.html*.

Drinking Water Standards

EPA sets national primary drinking water standards through the establishment of maximum contaminant levels (MCLs) and through treatment technique requirements.

MCLs are the maximum permissible levels of contaminants in drinking water that is delivered to any user of a public water system. The MCLs provide enforceable standards that protect the quality of the nation's drinking water.

Treatment techniques are procedures that public water systems must follow to ensure a contaminant is limited in the drinking water supply. EPA is authorized to establish a treatment technique when it is not economically or technically feasible to ascertain the level of a contaminant.

June 1996. The revised goal states that "by the year 2005, 50% of the population served by community water systems will receive their water from systems with source water protection programs in place."

Source water assessment and protection programs provided for under the 1996 Amendments to the SDWA offer opportunities and tools to protect drinking water at the source. They offer a unique opportunity to integrate not only drinking water programs so that they operate in a coordinated fashion, but also to integrate drinking water, clean water, coastal, solid and hazardous waste, agricultural, and other environmental management programs to better protect public health and the environment while reducing duplication of effort and program costs.

Drinking Water Concerns

Over 90% of people in the United States get their drinking water from public water supplies. Although most public water supplies meet drinking water standards, a diverse range of contaminants can affect drinking water quality. EPA's Science Advisory Board concluded that drinking water contamination is one of the greatest environmental risks to human health. This conclusion is due, in part, to the variability in quality of the source of water supplying the drinking water. It is also due to the potential for contamination in the delivery system as the water travels from the treatment plant to the consumer's tap.

Under the Safe Drinking Water Act, a public water system is defined as a system that has at least

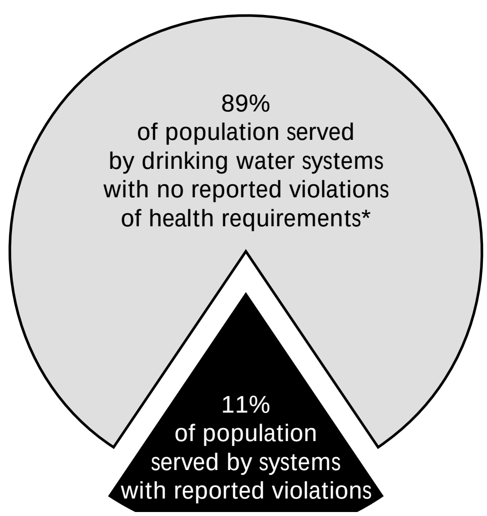
Figure 28

Figure 28

Compliance of Community Drinking Water Systems with Health Requirements in 1998

Population served by community drinking water systems in 1998 = 253 million

Number of community drinking water systems = 54,367



**As much as one-fourth of the community water systems did not complete all required monitoring. The compliance status of some of those could not be assessed from the data reported.*

Source: U.S. EPA, 1999, Office of Ground Water and Drinking Water, Washington, DC.

15 service connections or serves an average of at least 25 people for at least 60 days per year. There are three types of public water systems:

- Community water systems are those that serve the same people year-round (e.g., cities, towns, villages, and mobile home parks).
- Nontransient noncommunity water systems are those that serve at least 25 of the same people for at least 6 months of the year (e.g., schools, day care centers).
- Transient noncommunity water systems are those that serve transient populations (e.g., rest stops, campgrounds, and parks).

In 1998, 89% of the population served by community water systems (CWSs) received water that had no reported health-based violations (MCL or treatment technique violations). Ninety-one percent (91%) of the CWSs had no reported health-based violations (Figure 28). Of the 4,630 CWSs reporting health-based violations, 325 (7%) were systems serving 10,000 or more people. These systems together served 23 million people. The total coliform rule and the surface water treatment rule were violated most frequently by large water systems. Four percent of the 10,002 community water systems with a monitoring and reporting violation were large systems, serving a total of 22 million peple. The rules pertaining to synthetic organic carbon, volatile organic carbon, and the total coliform rule monitoring requirements accounted for most of these system's violations.

For public water systems in 1998, there were 128,459 violations reported by 36,467 of the 170,376 systems. Of those, 85% were violations of significant monitoring and reporting requirements and 12% were violations of MCL and treatment technique requirements. Eighty-five percent of these violations were in small systems serving 500 or fewer people.

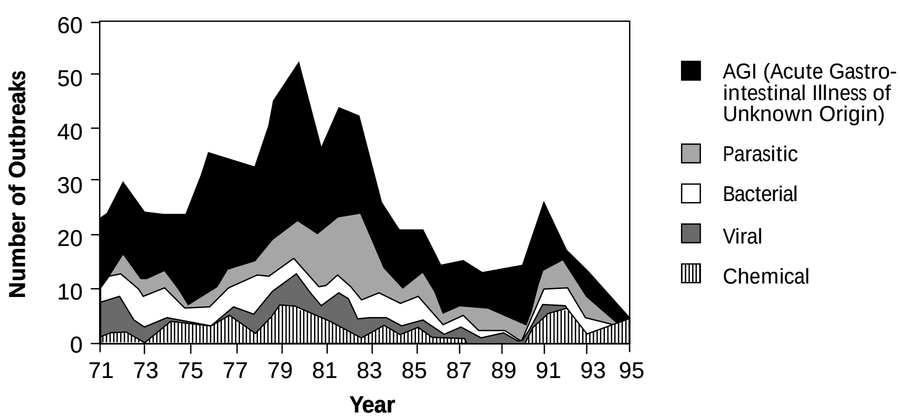
One risk from unsafe drinking water is exposure to waterborne pathogens, which can cause acute health problems requiring medical treatment. As shown in Figure 29, bacteria, viruses, parasitic pathogens, and chemical agents have all been shown to cause waterborne disease outbreaks.

For systems serving a large population, a waterborne disease outbreak can sharply impact a large number of people. The 1993 *Cryptosporidium* outbreak in Milwaukee, for example, affected more than 400,000 people, the largest waterborne disease outbreak ever reported in the United States.

> The new amendments offer a unique incentive for water utilities and groups devoted to watershed protection to form partnerships and explore their common ground. After all, the goals of one group often affect the goals of the other. For instance, water utilities generally strive to keep treatment costs down, while watershed groups typically look for ways to address sources of contamination. Identifying such common pursuits stands to benefit everyone and, ultimately, the future of the nation's watersheds.

Figure 29

Waterborne Outbreaks in the United States by Year and Type



Source: Levy et al., 1998, Morbidity and mortality surveillance summaries. *Surveillance for Waterborne Disease Outbreaks*, Centers for Disease Control, Atlanta, GA, V. 47(SS-5): 1-34. *http://www.cdc.gov/epo/mmwr*